VOLUME XXXI NUMBER 5

BOTANICAL GAZETTE

MAY, 1901

THE GENETIC DEVELOPMENT OF THE FORESTS OF NORTHERN MICHIGAN; A STUDY IN PHYSIOGRAPHIC ECOLOGY.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVII.

HARRY NICHOLS WHITFORD.

(WITH EIGHTEEN FIGURES)

PORTIONS of the summers of 1898, 1899, and 1900 were spent by the writer in studying physiographic ecology at several points in northern Michigan. The work of the first two summers was under the personal direction of Dr. H. C. Cowles, to whom the writer is indebted for many valuable suggestions. Indeed, the work set forth in the present paper is little more than the testing and working out in detail the ideas on physiographic ecology developed by Dr. Cowles in his lectures at The University of Chicago and in his published papers. Credit is due Mr. W. B. McCallum for the photographs used to illustrate this article, with the exception of *figs. 1* and *4*, which were obtained by Mr. E. N. Transeau.

It should be clearly understood that the conclusions reached are based mainly on observations and are presented tentatively. They are published in the hope that they may be thoroughly tested by other observers, and if necessary modified or discarded altogether. It is the writer's belief that only along lines similar to those advocated here can the problems of forest distribution be successfully solved.

I. FACTORS.

The factors to be taken into account in attempting to explain the relations that exist in different plant associations are so complex that it will be well to consider them in detail. Since the object of this paper is to answer some of the questions involved in the development of forests, special emphasis will be laid upon those factors which appear to be related to tree growth. In order to understand the distribution of trees the subject must be approached from both the negative and affirmative standpoints. In other words, the question is, why are there forests on certain physiographic formations and none on those which lie close by? Also within the forest itself there predominates now one and now another tree type. In some places the coniferous forest is prominent, in others the maple-beech-hemlock type is the chief feature. Indeed, if enough regions are studied an indefinite number of combinations may be observed. Thus not only must the presence or absence of trees be explained, but also where trees are present a reason must be given for the dominance of any particular kind of forest. If these questions can be answered satisfactorily, some light will be thrown on the origin and development of forests. In the answer three sets of factors are involved, climatic, ecological, and historical.

A. **Climatic factors.** The greater part of the eastern half of the United States is a potential forest. Here the two great climatic factors, *temperature* and *moisture*, are favorable to the development of forest trees. When a climate makes possible the development of any predominant type of vegetation that type is called a *climatic formation*.[1] To be specific, the eastern half of the United States has a *forest formation*. But if a bird's-eye view of any portion of this formation be obtained, there will be found within it groups of other plant types. These are designated by Warming[2] *plant societies*. Within this vast forest

[1] SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage. 1898.

[2] WARMING, E.: Plantesamfund. 1895. German edition, translated by Knoblauch. 1896.

formation there are prairie, beach, dune, heath, swamp, and other plant societies; also the forest itself may be divided into a number of different forest societies. This leads naturally to the consideration of those factors that make up the plant society conditions.

B. **Ecological factors.** For convenience this set of factors may be divided into edaphic, atmospheric, hydrodynamic, and biotic.

EDAPHIC FACTORS. Schimper[3] has regarded the soil and its properties so important that he has given the name *edaphic formations* to those *societies* which owe their existence to the peculiarities of the soil. More than any other form of vegetation trees need a firm anchorage medium, and hence a deep soil. Since the roots are the absorbing as well as the holdfast organs, the water content of the soil is important. Warming's classification of plant societies[4] into xerophytic, hydrophytic, and mesophytic is based upon the amount of water in the soil. More plant societies doubtless owe their characteristic physiognomies to the amount and condition of the water in the soil than to any other one factor. Since trees present a greater transpiration surface than other forms of plants they must occupy those positions where there is sufficient water to maintain the transpiration current. This excludes them from those regions where the water content of the soil approaches the minimum; a stagnant condition of soil water is likewise injurious to trees. Probably here the exclusion of air and the presence of humic acids prevent the healthy growth and activity of the root system. In order that the forest condition may be obtained, therefore, the soil must be well drained, as well as watered.

The physical properties of the soil play an important rôle, for upon them depends the capacity of the soil to hold water. The water-holding properties of the different kinds of soil are too well known to need treatment here. The heat-absorbing and heat-retaining qualities of soils must be taken into account, for they often determine the presence or absence of certain plants.

[3] *Op. cit.* [4] *Op. cit.*

Again, the soil furnishes the plant certain organic and inorganic compounds, and hence its chemical properties should be considered. As a rule, inorganic salts are present in sufficient quantities in the soil; indeed in salt marshes the presence of too great a quantity of salt in the water excludes trees, except in a few instances. Soils are more often deficient in organic compounds. Organic decay, since it furnishes most of the available nitrates, is of great importance. The amount of *humus* is so essential that it often determines the character of a forest, not only in furnishing the nitrogen to the plants, but also in ameliorating the physical properties of the soil. Nitrifying bacteria are necessary for the conversion of organic matter into nitrates, and if these are excluded the processes of organic decay discontinue, and consequently a condition like that present in sphagnum swamps is developed. Here, generally speaking, trees are excluded, except a few characteristic species.

We must look to the soil factors for an explanation of our most characteristic plant societies. There must be a soil. The water in the soil must be sufficient. The soil must be aerated. The amount of organic and inorganic compounds must not be too great or too little, and usually the soil must contain bacteria or other fungi for organic decay. If all these conditions are present in the right proportions, the soil is capable of supporting a luxuriant tree growth.

ATMOSPHERIC FACTORS. By atmospheric factors are meant those which influence the aerial parts of plants. They include radiant energy in the form of *heat* and *light*, and also the influence of *wind*. Of these light is the most important. The tree by virtue of its many planes of plagiotropic branches gives a greater surface on which the light may fall than is found in any other plant form. Principally because it has worked out this successful light relation, it is ecologically the culminating type of plant body. Once a dense forest is established, all forms of low vegetation, except those species that have special shade adaptations, are driven out. Attention has already been called to the necessity of heat as a climatic factor. Heat may also be

an ecological factor. In exposed situations the water and humus contents of the soil may be dried out. For example, a forest may be cleared and thus exposed to the sun's rays to such an extent that the soil factors will be changed considerably. It is obvious that it is difficult to separate the light and heat factors. While it is a benefit for a plant to get as much light as possible up to a certain point, along with the light the plant may absorb too much heat.

The carbon dioxid content of the air is so constant that it plays little or no part as an ecological factor. Those plants nearest the ground are slightly favored by the greater amount of carbon dioxid in the lowest layers of the atmosphere. The effect of winds on trees, however, is often pronounced in exposed situations. Besides destroying trees the wind may injure them to such an extent that in the struggle with disease and with other trees they will be the first to succumb. The wind is of great importance also in that it causes excessive transpiration. The effect of wind on seed distribution is so pronounced that, other things being equal, those plants whose seeds are most easily distributed will stand the best chance in a given area. In conclusion, therefore, the atmospheric factors of light, heat, and wind must be taken into account in trying to explain the presence or absence of certain plant societies.

HYDRODYNAMIC FACTORS. The term hydrodynamic is used here to designate the action of tides and waves upon strand vegetation, and the action of stream and ocean currents in distributing seeds. These factors may play an important part in determining the peculiarities of plant societies, hence the necessity of keeping them in mind.

BIOTIC FACTORS. Two plants cannot occupy the same soil at the same time. The struggle for a foothold in the soil may take place between species of the same kind or of different kinds. Again, the struggle may be between plant societies, as the forest and heath, or forest and prairie. The line along which two societies meet has been called the tension line. Here it is that the struggle is most pronounced. If the other ecological

factors remain constant, the tension line does not change. In that case, for instance, the forest does not advance on the heath nor the heath on the forest. But, as will be shown in the discussion of the historical factors, the conditions as a rule are changing constantly. Not only may the struggle be between the forest on the one hand and some other type of plant society on the other, but it may be between different kinds of forests.

The struggle between plants and animals may have an important bearing on the explanation of any given floral region. In civilized communities man has changed the whole nature of the vegetation. His influence is seen where forests are cleared for timber and fuel, or for purposes of cultivation; also indirectly where forest and prairie fires are active. Again in regions where stock is raised trees are damaged or kept from spreading by the ravages of domestic animals. Insect life may also be an important factor in explaining the floral character of a given region.

In concluding this discussion of the ecological factors, it is well to note again that the three great physical media—soil, air, and water—are all influential in bringing about certain plant physiognomies. These, together with the biotic factors, make that variety in the landscape of any region which is shown in the plant societies that are present.

C. **Historical factors**. The third great set of factors that play a part in the understanding of plant associations has been designated historical, for it involves the element of time. It means simply that the geological and physiographic forces have changed and are changing the factors so far considered as to make absolutely necessary a readjustment of plant formations and plant societies to meet the new conditions. Diastrophic movements may submerge large areas of land and thus destroy all terrestrial vegetation or force it to migrate to unsubmerged parts. On the other hand, when there is an addition to the land area a condition is obtained where there can be noted the successive stages in the reclamation of such an area by vegetation. Again, in the last glacial epoch the ice sheet in its advance destroyed vegetation and modified the climate beyond the limits of

its advance, so as to bring about an arctic vegetation where there formerly existed a temperate floral formation.

Erosive forces also come into play. The advance and retreat of the ice sheet changed the physiographic features. Drainage lines were dammed up and lakes were formed. It is the belief of glaciologists that the great lakes, at least in part, were formed in this way. Oscillations in the change of the front of the ice sheet changed the levels of lakes and left old beaches, other sand formations, and cliffs, thus bringing into existence new topographic forms and new soil conditions. With the final retreat of the ice sheet the normal processes of water erosion began again. Drainage lines became reestablished, and with the aid of decaying vegetation the lakes began to be filled up. The longer an area of land has been free from the ice sheet, the more nearly have its drainage lines become firmly established. It is evident then that the edaphic conditions in a region recently vacated by the ice will be decidedly different from those that have been exposed to the erosive force of water. The more nearly a region reaches base level the more stable will be the edaphic conditions. The recent work of Cowles[5] on the Chicago region shows clearly the successive stages in the advance toward the climax condition. He was also the first[6] to bring out clearly the dynamic conditions due to physiographic changes. It is evident that the existing plant societies must not be looked upon as fixed, but rather as changing from year to year; sometimes slowly, as in the case of swamps; or sometimes with rapidity, as in the case of dune societies.

II. THE SAND SOCIETIES.

The islands of North Manitou and Beaver at the northern end of Lake Michigan, the adjoining mainland on the Michigan

[5] COWLES, H. C.: The physiographic ecology of Chicago and vicinity; a study of the origin, development, and classification of plant societies. BOT. GAZ. **31**: 73–108, 145–182. 1901.

[6] COWLES, H. C.: The ecological relations of the vegetation of the sand dunes of Lake Michigan. BOT. GAZ. **27**: 95–117, 167–202, 281–308, 361–391. 1899. *Idem*: The physiographic ecology of Northern Michigan. Science **12**: 708, 709. 1900.

side of the lake, and the southern shore of Lake Superior in the neighborhood of Marquette, Michigan, offer exceptionally good fields for a study of the stages in the life history of the forest societies. North Manitou island, in general, consists of a clay core covered over and added to by sand formations, principally beach and dune. So complex are these in the interior that it is difficult to trace any definite time relations, and no attempt was made to do this. On the south and southeast ends of the island however, where the beaches and dunes are in the process of formation, it is not so difficult to discover the time relations. The northern portion of Beaver island and the mainland in the vicinity of Charlevoix, Michigan, have similar formations. On the southern shore of Lake Superior, while the beaches are present, the dunes are for the most part absent. The beach and dune societies have been so thoroughly studied by Cowles that attention need only be called to the points in his work essential to the understanding of the various stages in the life history of the forest of these regions.

THE LOWER BEACH. The lower beach is defined as that portion washed by the summer waves. There are a number of factors here, any one of which may exclude vegetation. Since the beach is the shore drift in transit, the very movement of the sand or pebbles may prevent plant life. The mechanical wash of the waves would uproot any plants that had obtained a foothold. Again, the border between the land and water presents at one time a xerophytic and perhaps the next moment a hydrophytic habitat. However, in protected places, or where the water is shallow for a distance from the shore, the breaker line thus being distant from the shore, a condition is obtained which may bring into existence a hydrophytic society. Wherever sand is accumulating along the shores in the region under discussion, the lower beach is prominent. With a further recession of the lake it may pass into the middle beach. It is considered, therefore, the first stage in the life history of the forest, for by the action of the waves a soil is made, the first requisite for any forest society.

THE MIDDLE BEACH. The middle beach is that portion of the shore drift in transit only during the winter months. It is consequently free from the waves during the growing season. Here, therefore, is a new land formation in which all the factors which prevent growth in the lower beach are eliminated for the brief space of one growing season. While the hydrodynamic factors have been eliminated, certain of the atmospheric, edaphic, and historical factors are detrimental. Since the former are considered in the initial stages of the upper beach society, they will be discussed under that head. In the short period that this beach is left untouched by the wave action, no plants of any consequence can obtain a foothold. This, together with the sterile soil of sand or pebbles and the extreme exposure to insolation, often prevents the growth of any species. In a few instances the annuals, *Cakile Americana* and *Corispermum hyssopifolium*, and the first year's growth of the biennial, *Oenothera biennis*, are present. If the new land thus made contained an alluvial soil stocked with seeds, one might expect a more or less abundant growth of annuals, though the insolation would still be very great, and would undoubtedly prevent a rich growth. Since the middle beach, by a further recession of the waters of the lake, may become a fossil beach, and thus reach, as will be shown later, a condition more near the forest, it is regarded as the second stage in the life history of the forest.

FOSSIL BEACH. The fossil beach is that portion of the shore beyond the reach of the hydrodynamic factors. In the initial stages the fossil beach is as barren of vegetation as the middle beach, and if in an exposed situation the wind (*fig. 1*) shifts the sand repeatedly, this condition is maintained for a greater or less length of time. If fairly well protected from winds, successive plant societies appear rather rapidly.

The well-known physical and chemical qualities of sandy soils need not be discussed at length here. While the upper layers of sand dry out rapidly, observations seem to show that the lower layers are moist up to high levels. However, the first few layers are extremely dry after a short period of drouth, due to

the rapid evaporation from the loose soil. The soil heats up and cools off rapidly, so that the variation in temperature in a short space of time is great, a condition unfavorable to plant growth. Nevertheless, in spite of the strong insolation and dry soil, if sufficient time elapses a definite fossil beach society is obtained. The enumeration of species is not of any consequence. They are at first mostly herbs, both annual and perennial. By their death, and in some instances by the decay of old logs left by storms when the beach was nearer the lake, humus conditions of the soil are gradually obtained. This is at first slow because of insolation. Nevertheless, each year adds its growth of herbs, and even though a greater part is dried out or blown away, in time the better humus condition will bring about the possibility of a higher type of plant society, so the fossil beach society gradually develops into a heath.

HEATH. The heath society is considered, in the normal development, the fourth stage in the life history of the forest. It will be well to keep in mind the changes that make possible the heath. These are the increase in the amount of humus and the element of time. *Juniperus communis*, *J. Sabina procumbens*, *Arctostaphylos Uva-ursi*, *Pteris aquilina*, *Zygadenus elegans*, *Solidago nemoralis*, *Campanula rotundifolia*, and *Comandra umbellata* are some of the characteristic plants of the heath. *Fig. 1* shows a heath at the foot of a coniferous forest on the lake side of a sand dune.

Now for the first time biotic factors assume some importance, though slight. In the first three stages the struggle of plants against adverse physical conditions gave plenty of room for all able to survive. Although the physical conditions are still unfavorable, in places plants like the junipers and bearberry may occupy considerable areas to the exclusion of others. In the open spaces between the individual shrubby plants, however, there is sufficient room for a large number of herbs. These by decay contribute humus to the soil, and since the insolation is not so great as in previous societies, a larger portion of the decaying vegetation is prevented from drying out. Thus as

the vegetation increases there is a gradually increasing increment of humus, and this constitutes a condition favorable to a higher type of plant society.

THE CONIFEROUS FOREST. It is not always easy to determine the conifer that first comes to occupy a place in the heath. If conclusions can be based upon a limited number of observations, the jack pine (*Pinus Banksiana*) is the most xerophytic (*fig. 2*). This is followed closely by the red pine (*P. resinosa*) and the white pine (*P. Strobus*) in the order named. This does not mean that anyone of these always appears to the exclusion of all others, though that is sometimes the case (*fig. 2*). Other things being equal, the more xerophytic the conditions the more likely is it that the jack pine will be the predominant tree, and the less xerophytic the conditions the more abundant the white pine. *Fig. 3* is a photograph of a pine forest in which the red pines form a large proportion of the trees. In this forest are a number of white and jack pines. If the succession as given above be correct, it means that this forest is probably a transition between the jack pine society and a white pine society. In the ideal case, then, the succession of predominant species is in the order named. The drier and perhaps the colder the climate up to a certain point, the more likely is this succession to be realized. Thus, in the Marquette region almost pure jack pine forests are found, while at North Manitou island, where the climate is more uniform, the jack pine stage is almost eliminated. Very often the balsam (*Abies balsamea*) (*fig. 1*) and hemlock (*Tsuga Canadensis*) occupy a prominent place in the coniferous forest.

The first stages of the pine forest society are seen in the appearance of a number of trees in the later stages of the heath. For the first time in the normal development of the plant societies the tree has to be taken into consideration. In the tension zone between the heath and forest the trees are more scattered near the heath, and become gradually thicker as the forest is approached. The territory between the trees, where not shaded, is usually occupied by a growth of the heath plants already named. Thus, gradually the pines advance on the heath, and in time come to

occupy its territory. In the young pine forest near the tension zone there are often found scattered trees of the white birch (*Betula papyrifera*), oak, and the poplars (*P. tremuloides* and *P. grandidentata*). As the forest reaches maturity, these are usually crowded out, the birch being the last to disappear.

Thus, with time and with the gradual increase of humus, the pine forest society is established. As a rule, the white pine seems to occupy the tension zone between the coniferous and the deciduous forests. If the climate be unfavorable for a higher type of forest tree, however, a stage beyond the white pine forest is not reached. If the forest be not too open, and if surface fires are absent, the deep shade established by the pines means that the edaphic and atmospheric factors have become favorable for establishing the climax forest of the region.

MAPLE, BEECH, AND HEMLOCK FOREST. Beginning with the middle beach we have seen that in each successive society a gradually increasing quantity of humus has been added to the soil, until a white-red pine forest is established. The pines add their quota of vegetable decay to the humus. The xerophytic soil thus becomes more and more mesophytic, and *pari passu* it has become more and more shaded. The humus means that the almost sterile soil of the beach has become richer in organic compounds, and by the aid of fungi and bacteria more nitrates are added. The capacity of the soil to hold water is likewise increased. The better edaphic and atmospheric conditions make a natural nursery for the growth of beech (*Fagus ferruginea*) and maple (*Acer saccharinum* Wang.) seedlings. The white pine does best in the richer soil conditions, but its seedlings require more light than they can obtain in the shade of the forest. As the maple and beech attain maturity, they come to occupy a prominent place in the forest, and a mixed pine-deciduous forest is the result. The broad-leaved deciduous trees produce a still deeper shade, so that if any pine seedlings are able to survive in the pine forest, the increasing shade will finally make it impossible for a new generation of pine trees. The development of beech and maple seedlings, however, is not

affected by the shade of the parent trees. In the midst of the deciduous forest isolated white pines are often seen rising above their neighbors, and thus stand as relics of a previous pine forest. A pine starting from a seedling condition with young deciduous trees as a rule never reaches a height greater than that of the trees among which it is growing. At the same time the girth of such a tree is much greater, owing to the better soil conditions, than it would be were it growing among its kind, where it must necessarily grow taller or be crowded out in the struggle for light.

The place of the hemlock in the pine and deciduous forests is a peculiar one. It often composes 10 per cent. of the trees in a white pine forest, and may reach as high as 50 per cent.[7] It seems to be of about the same age as the trees with which it grows, and hence probably started with them. This probably means that its seedlings are able to develop like those of the pines, without being shaded. Yet it often occupies a prominent place in the deciduous forest (*fig. 4*), even when the shade has become so dense as to exclude any chance for the development of white and red pine seedlings. It apparently occupies this position among the maple and beech because its seedlings can endure shaded conditions, although they do not thrive in such situations. Dwarfed young trees fifteen or more years old are often found in the densest shade possible. These develop slowly, until an open place is made by the death of the older trees around them, when they spring rapidly into prominence and occupy a position equal to that of the maple and beech. Like the white pine, the hemlock will flourish in the more xerophytic places, but prefers the deciduous woods and does best in them. The balsam also occupies a position similar to that of the hemlock, although it is seldom present in a mature climax forest. The yellow birch (*Betula lutea*) has a constant place with the beech, maple, and hemlock. It is more plentiful in the Marquette region than farther south, but seldom constitutes more than a small percentage

[7] SPALDING, V. M., and FERNOW, B. E.: The White Pine Bull. 22. U. S. Department of Agric., Div. of Forestry. 1899.

of the total number of trees. The beech is absent in the Marquette region, and the significance of this is not clear. It may be due to the fact that the climate is not favorable for its development. It is present, however, in the northern peninsula east of Marquette.

The whole interior of North Manitou island (*fig. 4*), except in clearings and undrained areas, is covered with a mature maple-beech-hemlock forest. The presence of seedlings and young trees of these three in abundance and the absence of all other young trees in their shade indicate that the future forest growth will be the same as the present. The climax forest in places reaches nearly to the shore of Lake Michigan, restricting the coniferous and heath societies to very narrow belts. If the present shore line should remain constant, and if the natural succession of plant societies were not interfered with by man, undoubtedly the whole island would in time become completely covered with a deciduous forest save a narrow strip, the last remnants of a coniferous forest, next the water's edge.

The undergrowth in the dense shade of the maples, beeches, and hemlock is scanty. *Taxus Canadensis* and *Mitchella repens* are usually the most abundant. The spring plants are characteristic, but their vegetative period is confined to the leafing time of the trees under which they grow, so that by midsummer only traces of the many forms survive. The loose sandy soil is favorable for creeping underground stems. Lianas are entirely wanting. This is probably due to the lack of sufficient light and heat, for in the open woods farther south the liana habit is common, and as one approaches the tropics the increasing warmth, even in dense shade, favors a luxuriant growth of lianas. Epiphytes, except mosses, liverworts, and lichens growing on the bark of trees, are also absent.

Aspidium spinulosum intermedium, *A. marginale*, *Lycopodium lucidulum*, *L. inundatum*, *Actaea alba*, *Goodyera pubescens*, *Osmorrhiza brevistylis*, *Maianthemum Canadense*, *Monotropa uniflora*, *Corallorhiza odontorhiza*, and *Epiphegus Virginiana* are among the most common plants that occupy a place in these forests.

The humus in the soil is usually variable in amount, but is most plentiful where fallen logs have decayed. Hummocks of soil rich in humus mark places where dead trees when uprooted brought with them quantities of earth. The decaying logs are covered with fungi and mosses. Indeed the soil itself is full of a living mass of hyphæ. The recent researches of Stahl[8] show that mycorhiza is the exception rather than the rule. The rôle that mycorhiza plays is problematic. Some plants, the European beech among them, are entirely dependent upon these root-fungi, for when grown in sterile soil they perish. This seems to indicate that the beech cannot thrive in soil without humus, for its root-fungus is dependent upon organic decay for its existence. In other words, the absence of humus means the absence of mycorhiza, and its absence excludes the beech. Indeed, future investigation may show that a large majority of forest trees and other forest plants have established an obligate mutualistic relation with root-fungi.

THE DUNE SOCIETIES. In discussing the sand societies the conditions favorable to the formation of dunes have been disregarded. Where the wind sweeps across the fossil beach the succession of plant societies is retarded. The extreme exposure to the xerophytic influence of the wind often prevents the presence of plants. Nevertheless, when not too severe, a definite beach society is finally attained. The origin and development of dunes and dune societies have been clearly shown by Cowles.[9] It is only necessary to emphasize the fact here that the plant succession on dunes is similar to that on the beaches, and that in time the climax maple-beech society is reached. *Fig. 1* is from a photograph, showing a fossil beach society in the foreground. On the right is a dune clothed with a coniferous forest. At the base of the dune is a heath encroaching upon the beach. On the landward side of this dune there are indications of the beginnings of a maple-beech forest, and farther inland are dunes

[8] STAHL, E.: Der Sinn der Mycorhizenbildung. Jahrb. f. wiss. Bot. **34**: 539–668. 1900.

[9] Sand dunes of Lake Michigan, BOT. GAZ. **27**: 95 ff.

which have passed through the first stages into mature climax societies. Dunes clothed with maple-beech forests are also found along the Michigan coast in a number of localities. It is difficult to understand how such a mesophytic plant society is attained, unless it be assumed, as observation seems to indicate, that by capillarity, water may rise from the ground water level to considerable heights in sandy soils.

III. THE CLAY SOCIETIES.

There are greater difficulties in tracing the life-history of clay societies than of sand societies, principally because there is not such a perfect sequence of clay formations at the present time as of sand formations. With the exception of sea-cliffs and clearings, clay soil formations free from vegetation date back to the time of the retreat of the last ice sheet. Sea-cliffs, however, formed by the action of the waves on glacial clay, are a common feature along the shores of Lake Michigan. Here the waves are constantly undermining the cliff, and thus prevent anything more than a transient vegetation. But should the débris at the foot of the cliff become too great for the shore current to transport, or should a recession of the waters of the lake leave a cliff beyond the reach of the waves, the undermining would cease. Here then at the outset is a clay bluff almost free from vegetation.

The reclamation by plant growth begins at once. The first stage in the life-history is represented by herbaceous plants like *Solidago humilis*, *Aster laevis*, *Elymus Canadensis*, *Prenanthes alba*, etc. Later on xerophytic shrubs like *Shepherdia Canadensis* and *Juniperus communis* give a heath-like physiognomy to the bluff. Again, a third stage is reached in the appearance of conifers, poplars, and white birch. These stages are more rapid, for clay soil retains moisture more readily than the sandy soils. The action of humus on clay is exactly the reverse of its effect on sand, for it loosens up the soil and renders it much less soggy than it would be were it free from organic decay. Where the cliff has been long enough freed from the action of the waves,

in due time a maple-beech-hemlock condition is the result. Thus, starting with an herbaceous vegetation similar to that on the fossil beach, there is a transition through the heath and coniferous forest to the climax society. Making due allowance for difference in climate, it is probable that all the glacial clay

FIG. 1.—The lakeward slope of a sand dune on North Manitou island covered by a forest. Balsam is the most common tree. The undergrowth is very dense, and the deep shade furnishes favorable conditions for the development of maple and beech. The evergreen forest is encroaching on the evergreen heath seen at the foot of the slope, and the latter, in turn, is encroaching on the fossil beach society situated in the foreground.

lands in the region under discussion have passed through somewhat similar stages, since they were formed by the action of the last ice sheet. As a rule, where the vegetation has not been disturbed by man, they are clothed with maple-beech-hemlock forests. Where clearings are made, as will be shown subsequently, they rapidly attain the same forest condition if let alone.

IV. THE ROCK SOCIETIES.

The pre-Cambrian rocks of the Marquette region furnish an excellent field for the study of the succession of plant societies. The rocks are mostly granites and quartzites. The chemical nature of the rocks seems to have little influence on the ultimate plant society that is obtained, but the ease with which they disintegrate is different, therefore the rapidity of the succession of plant growth is influenced. Other things being equal, granites, because of their heterogeneous structure and consequently differential weathering, will furnish a soil more quickly than the homogeneous quartzite. In the region under discussion the rocks have not only been worn and polished smooth by the action of the last ice sheet, but since then have lain beneath the waters of the former extension of Lake Superior. Indeed, some of them have only recently emerged from the lake. Thus just as there are beach lines of different ages, so there are rock areas of different ages. Other things being equal,

FIG. 2.—Jack pine forest on a fossil beach near Marquette. The absence of undergrowth is due to repeated surface fires.

the longer the rocks have been subject to sub-aerial influences the more nearly they approach the condition of the climax plant society.

On the sand formations at the contact of the lake with the shore the hydrodynamic factors absolutely prevent plant growth.

FIG. 3.—Norway pine forest on an old beach near Marquette. This forest also contains a few white and jack pines.

Here likewise, where the rocks dip beneath the lake, there is a zone of no vegetation. However, often within the reach of not too active waves lichens are found. Many lichens need no soil; such are essentially lithophytes and are soil makers. They are fastened firmly to the rocks by holdfasts which secrete acids that aid in disintegrating the rocks on which the lichens grow. Lichens receive moisture from the rain that falls on them, or, when near the water's edge, from the wash of the waves. Between rains they dry and curl up, but are uninjured, for after

the next rain they are as fresh as ever. Nitrogen compounds are obtained from the rain water or from particles of dust which lodge around them and other requisite inorganic compounds come from the rocks. Thus these pioneers of vegetation, as has been

FIG. 4.—A maple-beech-hemlock forest in sandy soil on North Manitou island. The undergrowth consists principally of maple, beech, and helmlock seedlings and young trees; also *Taxus Canadensis* and *Mitchella repens*. The young trees indicate that the next generation of trees will be the same as the present.

shown by various writers, are able to flourish in the most xerophytic situations. They not only aid in disintegrating the rocks, but by decay furnish humus constituents to the soil, and in these ways, *pari passu*, both organic and inorganic soil is made.

If the lichens be on not too steep a slope they will in themselves furnish soil enough to maintain a higher form of plant life. Xerophytic mosses gain a foothold as soon as a slight soil is made. These, too, by decay aid the lichens in forming a soil

FIG. 5.—A granite rock covered by the lichen *Cladonia rangiferina*, moss, and herbaceous plants. To the right are conifers growing in the crevices of rocks.

that will support still higher forms. *Fig. 5* shows such a society. It is even possible, in time, without the aid of inorganic processes of weathering to establish a soil capable of supporting a tree vegetation. However, inorganic processes of weathering are going on continually. Changes of temperature, etc., crumble the rocks and form crevices in which soil lodges. Since most of

the rock surfaces are not level, the soil made by lichens and mosses is washed into the crevices or into hollows made by the action of ice or water erosion. At once a herbaceous and shrubby vegetation springs up. Plants like huckleberries, goldenrods, *Potentilla tridentata*, *Campanula rotundifolia*, and the bearberry gain a foothold in the crevices. These are followed by arbor vitae (*Thuja occidentalis*), the junipers, and the pines. *Fig. 6* shows a rocky island in a bay near Marquette. At a distance

FIG. 6.—A granite island in Lake Superior near Marquette. At a distance it appears destitute of plant growth.

it looks barren of vegetation, but a closer view (*fig. 7*) shows that it is not altogether destitute of plant life. *Fig. 8* is from a photograph of a larger island near by which shows a much higher type of vegetation, for here are found red and white pines. The weathering process is greatly aided by the prying action of roots. *Fig. 9* shows a red pine whose roots have split and raised a granite rock.

One of the noticeable features of rock vegetation is its variety. Within the limits of a few square rods miniature representations of all the great plant societies are found. Near a *roche moutonnée*, as smooth and as barren of vegetation as the day the ice sheet left it, is a small depression containing a swamp, in which sphagnum moss and the cranberry are found growing. Near by is a lichen society; this may grade into a

heath such as is shown in *fig. 5*, and this in turn may border on a small group of pines.

As in the sand and clay series, the mesophytic forest is not reached until first preceded by a coniferous forest. The coniferous forests on the rocks are at first very open, but ultimately

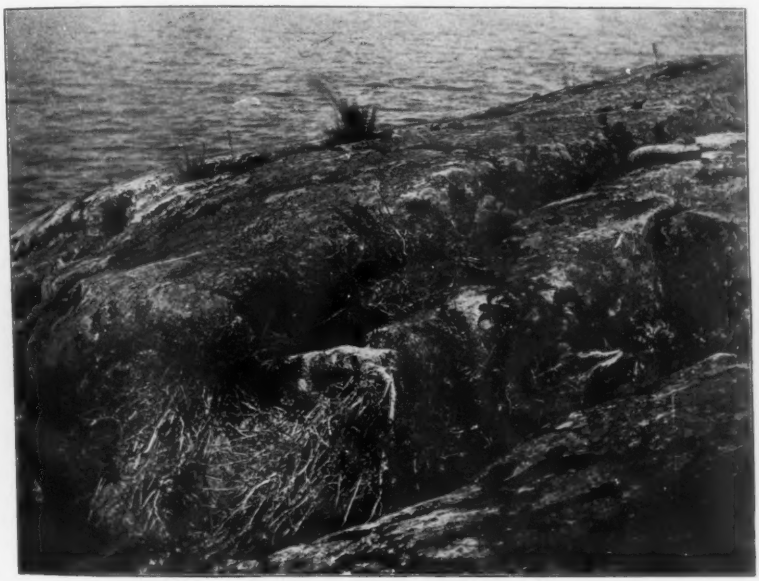


FIG. 7.—A near view of a portion of the island shown in *fig. 6*. On the faces of the rock are shown lichens and mosses. In the crevices are a number of herbaceous and woody plants; among them are goldenrods, poplar, arbor vitae, huckleberry, ninebark, Juneberry, wild red cherry, *Campanula rotundifolia*, and *Potentilla tridendata*.

the gaps are filled up, sometimes with birch and poplars, and thus a condition is obtained for the maple-hemlock forests. Some rock hills near Marquette illustrate these points. *Fig. 10* is a view from Sugar Loaf. The top of this hill is almost barren of vegetation. Obviously this would be the case, for the soil that is formed descends to lower levels; in the case of steep

slopes gravity alone is sufficient, while on all slopes the transporting power of rain water comes into play. Usually at the foot of the hill and sometimes well up the slope the conditions are favorable for the climax society. Other hills (*fig.* 17)

FIG. 8.—Portion of an island near the one shown in *figs.* 6 and 7. Here the vegetation is further advanced. Besides lichens, etc., white and Norway pines are found.

farther in the interior are completely covered with pine and deciduous forests.

V. THE SWAMP SOCIETIES.

One of the most characteristic features of a young glacial topography is the large number of lakes. In general these may be divided into two classes according to their mode of origin. One class is due to the action of the ice sheet. Depressions

may be made directly by the moving ice, or glacial deposits may dam up drainage lines. A second and subsequent class of lakes is made by bars cutting off lagoons from the larger lakes, or by spits formed across their embayments. Both classes have a similar life-history. Some find outlets and ultimately pass out of existence through the normal stages in the life-history of a river. A larger number, however, never find outlets, but are silted up by the wash of the surrounding soil, and by the accumulation of vegetation. Thus swamps are formed, and since they may represent a stage in the life-history of the forest they deserve treatment here.

FIG. 9.—A Norway pine growing from a crevice in granite; the rock has been cracked and uplifted by the growth of a root.

The zonal distribution of plants in swamps is one of the stock illustrations of ecologists, so that development of the various zones need only be mentioned briefly. Most swamps start as ponds or lakes, in which water lilies and other pond plants dominate. On the borders of the pond sedges appear; these, by their decay,

build up a soil, and thus prepare the way for the next zone, the Cassandra-sphagnum vegetation. The sedges encroach farther on the original lake. The Cassandra-sphagnum zone makes conditions possible for a tamarack-spruce zone (*fig. 11*). Thus each successive zone is pushed farther and farther toward the center. Finally the lily center disappears, and then successively

FIG. 10.—A general view of granite rock vegetation as seen from a granite hill (Sugar Loaf) near Marquette. On the margin of the lake the rocks show the first stages in the life-history of a forest. As the foot of the hill is approached the vegetation becomes more and more mesophytic until a mixed conifer and deciduous forest is attained. Probably in places this condition is reached more rapidly because of the presence of glacial drift. At the top of the slopes the xerophytic condition of the lake border is again attained.

the sedge and Cassandra zones, until a tamarack forest may come to occupy the whole territory.

Attention has already been called to the probable factors unfavorable to a high development of plant life in these swamps. These are due in the main to undrained conditions. The accumulation of humic acids may cause, osmotically, a drying-up effect. Insufficient aeration of the soil prevents a healthy growth of the root system of highly organized land plants, and also bars the

presence of nitrifying bacteria. These probably bring about the xerophytic structures of plants so commonly seen in hydrophytic habitats.

The areas around the swamp, whether clay, sand, or rock, have been undergoing their normal changes, so that the swamp is eventually surrounded by a forest. The swamp is finally built

FIG. 11.—A lagoon cut off from Lake Superior by a beach line, resulting in an undrained swamp. In the foreground is seen a portion of the original lagoon; back of this is the sedge vegetation, and near the conifers is a Cassandra zone. The conifers are mostly tamaracks (*Larix Americana*).

up high enough above the water level to permit a higher type of tree to occupy the area. Thus the tamarack is gradually crowded out, and a climax forest is the final stage.

The life-history is not always as indicated above. The swamp may become partially drained, but still be too wet to support the highest tree society. In that case the abor vitae gradually replaces the tamarack. Associated with the arbor vitae are the ash (*Fraxinus* sp.), the balsam, the white pine, and the yellow birch. Gradually, however, the arbor vitae swamps

give away before the encroaching mesophytic forests. *Fig. 12* shows a hemlock-maple forest bordering an arbor vitae swamp. In wet springy soils the arbor vitae forest is also found. *Fig. 13* shows a young forest in such a situation.

VI. CLEARING SOCIETIES.

Thus far what has been called the normal life-history has been traced. The influence of human agencies, with few exceptions, has been disregarded. By far the greater number of areas studied show unmistakable signs of the devastating influence of man, though less so on the islands visited than on the mainland. These clearing areas cannot be disregarded if a complete history of forest development is to be written. At first the difficulties of getting any order out of the tangle seemed insurmountable, and the notes were usually headed "clearings, conditions artificial." The literature on the subject of plant succession in clearings is confusing. It consists, as a rule, of records of isolated observations without any attempt at correlation. That there is some solution to the problem was the writer's firm belief, and after collecting a large number of notes the study began to yield results.

If the factors controlling the normal development as given above are correct, they ought to dominate in the clearing societies. With two exceptions, the stages observed in the development of these clearing societies are represented in the normal history. These exceptions are the "fireweed" and the poplar-birch societies. To explain these it was found necessary to give prominence to the fact that some plants migrate more easily than others.

If a deciduous forest be destroyed and burned over so that the surface débris is partially reduced to ashes, it will usually be found that the humus conditions of the soil are then reduced toward, but not necessarily to the conditions obtained in the heath. The equilibrium that had been established has been disturbed, and other things being equal all plants will have an equal chance provided their seeds are present. Shade plants, however,

including young plants of beech and maple, are excluded because the insolation is great. Some few plants that seem to prefer more xerophytic conditions likewise will not thrive. Then the struggle is narrowed to those plants that can endure strong insolation, that prefer tolerably good edaphic conditions, and whose seeds are present. It is obvious that those plants in the neighborhood that have the lightest seeds will have the largest representation of seeds on the ground first, and of these the most rapid growers will prevail the first year or two. The so-called "fire-weeds" meet the requirements best. *Epilobium angustifolium*, *Erigeron Canadensis*, and certain goldenrods spring at once into an occupancy of the field, and there is given a "fire-weed" physiognomy to the clearing (*fig. 14*).

FIG. 12.—A hemlock-maple forest bordering on an arbor vitae swamp. The tangled growth of the arbor vitae swamp is seen in the foreground. The hemlocks are encroaching on the arbor vitae.

The poplars (*P. tremuloides* and *P. grandidentata*) and the

white birch are the trees which have seeds adapted for rapid migrations, and are also rapid growers. Because they are perennial, and can thus get an early start each year after the first, they soon overtop the fireweeds and gradually shade them out. *Ostrya Virginica*, *Prunus Pennsylvanica*, *P. serotina*, and *Quercus rubra* are in some places associated with the poplars and birches.

FIG. 13.—A spring hillside with young growth of arbor vitae. The hill in the background has been cleared of a maple-hemlock forest and is used for a pasture.

In the absence of pine trees in the vicinity to furnish pine seeds, this poplar-birch society is maintained until deep shade conditions are again obtained for the growth of the maple-beech seedlings. Then, just as in the normal development the pines are replaced by the maples and beeches, so in the clearing development the poplar and birches are likewise replaced. The poplars go first, then usually the birch and hornbeam, and finally the cherry trees drop out.

If, however, pine trees in the vicinity of a clearing can furnish seeds, the pines occupy a place in the life history. The

more unfavorable the humus conditions up to a certain limit, the more likely is the clearing to have a pine aspect. The humus in the soil may be so reduced as to be incapable of supporting a poplar-birch growth. *Fig. 15* shows a young jack pine growth.

FIG. 14.—A hemlock-maple forest destroyed by fire. The rich growth of fireweed (*Epilobium angustifolium*) indicates the first stage in the life-history of a second-growth forest.

In this repeated fires have probably so reduced the humus conditions of the soil that the most xerophytic of the pines alone is able to gain a foothold. If favorable for the presence of both pine and poplar-birch growth (*fig. 16*), the pines in time overtop the poplars and birch, until a condition corresponding to the normal life-history is attained, viz., a pine society preceding the maple-beech society.

It can be seen readily that it is possible to obtain all stages of reduction between mesophytic and xerophytic conditions. This depends on what stage in the normal life-history is attacked by the fire, and on the intensity or entire absence of subsequent fires. Thus all possible combinations are represented. *Fig. 17*

FIG. 15.—A young jack pine forest on a fossil beach near Marquette. The humus content of the soil has been much reduced by insolation and repeated fires. The undestroyed Norway pines in the background probably indicate that the beach had formerly attained the Norway pine stage in the life-history series.

shows a maple-hemlock forest that has been nearly destroyed by fire. This is situated on the slope of a quartzite hill, and had probably reached the climax condition. In places the fire has left remnants of the forest, and even where the trees are destroyed certain geophilous forest herbs like *Clintonia borealis* have maintained themselves in the shade of half burned logs, while near by fireweeds, poplars, and pines are found. *Fig. 18* shows an almost pure birch forest. Not far away, however, are

found poplars mixed with the birch. In this neighborhood stumps of pines indicate the former forest. In places repeated fires have reduced the area to heath conditions. This is shown by a number of heath plants like *Pteris aquilina*, *Gaultheria procumbens*, *Cladonia rangiferina*, etc. The presence of few seed-produc-

FIG. 16.—A second-growth forest of pines and poplars on a fossil beach near Marquette. The pines are slowly gaining ascendancy over the short-lived poplars and these will in time disappear.

ing pines in the neighborhood will probably account for the absence of many pine seedlings.

Thus, no matter how far toward the first stage in the life-history a forest is reduced, if not interfered with by human agencies, ultimately the climax forest society is reached, but not without first having passed through a pine or a poplar-birch stage. A maple forest was never observed to follow a maple forest except

when the stools of a cleared forest are capable of producing sprouts. These may in time reach tree dimensions, though usually not before a considerable number of pines, birch, or poplars spring up between them.

Thus it will be seen that if human agencies should cease to

FIG. 17.—A partially destroyed hemlock-maple forest on the slope of a quartzite hill (Mt. Mesnard) near Marquette. The forest had attained the climax stage in the life-history series.

operate, all classes of topographic forms will ultimately come to be clothed with the climax forest growth. There is no reason why even the jack pine barrens may not in time reach this state. It must be remembered that these are late topographic features, or are reduced by repeated burnings to a soil poor in humus.

VII. CONCLUSIONS.

The life-history of the vegetation of four sets of physiographic formations has thus been traced. It has been shown that in each series the climax plant growth is a deciduous-hemlock combination. These physiographic formations have been treated separately because usually they are distinct from one

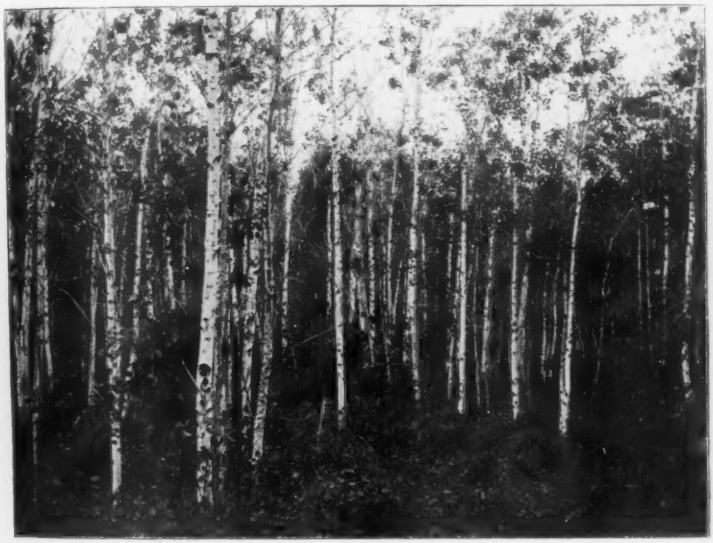


FIG. 18.—A white birch clearing growth on a fossil beach near Marquette. The undergrowth consists of *Pteris aquilina*, *Diervilla trifida*, etc.

another. In some instances, however, clay is mixed with rock débris or underlies the sand. The only effect such a mixture has is to hasten the succession of stages, for the advance toward the climax is more rapid on clay than on other soils. Principally for this reason the clay soils on the whole are already covered with the climax forest. In many instances the sandy soils have likewise attained the last stage in the life-history. Especially is this so where free from the influence of man as on

North Manitou island. But the succession of plant societies is much slower on sand than on clay soil, hence the prevalence of pine forests on the former. The reasons for believing that ultimately these pine forests will give way to the deciduous have already been given.

It is the belief of the writer that with some modifications the principles brought out in the foregoing pages will hold for all regions climatically capable of supporting a tree vegetation. The region under discussion is physiographically young. If the terms of physiography be adopted for ecology, a region having scanty vegetation may be considered young, while from this there will be all stages through maturity to old age, viz., a mesophytic climax forest. It would appear to the casual observer that northern Michigan is a region physiographically young and ecologically old. But no inconsiderable portion of the area of both Michigan and Wisconsin is occupied by swamps and lakes (including the great lakes). These will remain hydrophytic and hence ecologically young until filled up or drained. This condition is not attained until the region reaches maturity. The whole region, from an ecological standpoint, therefore, cannot reach maturity until it does so physiographically. Thus the development of the forest is in a measure held back until the normal physiographic processes extinguish the swamps and lakes. When these are eliminated, the region will reach old age from the vegetation standpoint much sooner than it does physiographically, because the climate is favorable for the extension of mesophytic forests into altitudes which would otherwise support only a xerophytic society.

In an area where the climate is more severe for tree growth the life-history stages are less rapid, for even though the region may be nearer base level the climax stages are more restricted. For example, Cowles[10] has shown that in the Chicago region, as a rule, the river bottoms contain the mesophytic plant societies, while the clay hills have only attained a semi-mesophytic forest

[10] BOT. GAZ. 31 : 88 ff. 1901.

of oaks and hickories. Such clay hills in northern Michigan are usually covered with the climax forest.

Again, as one approaches the semi-arid regions of the West, he will observe that the forest growth on the hills becomes less and less mesophytic until finally it gives way altogether to the prairie society. At the same time, the river bottom forests also become less mesophytic and more restricted to the banks of the streams. Ultimately, they, too, in the region of the great plains pass from existence and the prairie reaches to the very margin of the drainage lines. The writer has made some studies at various places in Kansas in reference to these points, and it is his intention to discuss them in full in a future paper on the ecological relations of prairie and forest.

THE UNIVERSITY OF CHICAGO.

MEXICAN FUNGI. III.

E. W. D. Holway.

The descriptions of the following new species were sent to me in German by Dr. Dietel. I am under many obligations to Professor Robinson of the Gray Herbarium, and to C. G. Pringle for the determination of the host plants. A large collection of Uredineae yet remains to be studied.

Uromyces Celosiae Diet. & Holw., n. sp.—Sori hypophyllous, sometimes on indistinct yellow spots, small or medium-sized, scattered or often thickly covering the leaf; uredosori cinnamon-brown; uredospores elliptical or globose, sometimes obovate, 27–34 × 24–26 μ; epispore thick, thinly covered with strong spines, with two germ-pores, brown; teleutosori dark brown; teleutospores elliptical or globose, coarsely verrucose, chestnut-brown, apex with a light colored rounded cucullate or papilla-like thickening, 28–38 × 22–30 μ; pedicel hyaline, as long as the spore, or a little longer, easily separating at the base from the host-plant, swelling in water.

On *Celosia latifolia*, Oaxaca, October 17, 1899, no. 3641.

Uromyces venustus Diet. & Holw., n. sp.—Aecidia hypophyllous, single or in small groups, hemispherical, opening at apex by a small pore; aecidiospores globose or elliptical, 20–25 × 29 μ, finely verrucose, teleutosori epiphyllous, opposite the aecidia, often in a circle, the center of which is the aecidium on the opposite side of the leaf, variable in size, sometimes confluent, naked, pulverulent, dark brown; teleutospores ovate or elliptical, sometimes almost globose, 32–40 × 20–28 μ, chestnut-brown, apex light brown, beak-like; epispore thick, with longitudinal lines; pedicel about the length of the spore, thin, hyaline, easily breaking at the base from the host-plant.

On *Cestrum nitidum*, Amecameca, October 31, 1899, no. 3759. Easily

distinguished from *U. Cestri* Mont. by the papilla at apex, and by the lines on the epispore.

Uromyces Oaxacanus Diet. & Holw., n. sp.—Sori epiphyllous, irregularly scattered (occasionally a sorus on the under side of the leaf), small, pulverulent, black; teleutospores ovate, elliptical or almost globose, frequently angular and irregular, 25–35 × 18–24μ; epispore chestnut-brown, not thickened at apex, verrucose; pedicel hyaline, hollow, somewhat longer than the spore.

On *Jatropha urens*, Oaxaca, October 21, 1899, no. 3690.

Uromyces dolichosporus Diet. & Holw., n. sp.—Uredosori mostly hypophyllous, scattered, dark brown, partly with spermogonia on the upper surface of the leaves; uredospores obovate, dark brown, 33–47 × 23–27μ; epispore thickened at apex and often at the base, echinulate, with three germ-pores; teleuto sori of medium size, hypophyllous, rarely epiphyllous, scattered or in small circular groups, orange-yellow when fresh, becoming white and felt-like; teleutospores long-fusiform or long-clavate, 45–65 × 12–18μ; with a thin hyaline smooth epispore, and germinating as soon as mature; pedicel firm, about the length of the spore.

On *Tournefortia velutina*, Oaxaca, October 18, 1899, no. 3655.

Uromyces Rubi Diet. & Holw., n. sp.—Spots circular, about 5^{mm} in diameter, occasionally confluent, yellow; sori epiphyllous, small, white when dry; uredospores elliptical, obovate, or globose, 23–35 × 18–25μ; epispore hyaline, with stout spines; teleutospores elliptical or clavate, 26–35 × 17–24μ, with a very thin hyaline epispore; pedicel short; spores germinating at once.

On *Rubus*, Cuernavaca, May 17, 1898, *C. G. Pringle*.

Uromyces Polymniae (P. Henn.) Diet. & Holw.—Uredo is *U. Polymniae* P. Henn. Teleutosori scattered, hypophyllous, single sori here and there on the upper surface, brownish black, naked; teleutospores elliptical or almost globose to pyriform, sometimes

truncate at apex, 30–45 × 20–30μ; epispore smooth, strongly thickened at apex, brown; pedicel firm, tinted, up to 75μ long.

On *Polymnia maculata* ?, Rio Hondo cañon, near city of Mexico, October 4, 1899, no. 3562; October 30, 1899, no. 3562B. On *Polymnia maculata*, Patzcuaro, October 10, 1899. The latter host shrubby, 10–15 feet high; the former herbaceous only, 4–5 feet high.

Uromyces Indigoferae Diet. & Holw., n. sp.—Sori epiphyllous, sparingly hypophyllous, scattered or in little groups on dead brown spots, and also on the petioles and young fruit, small, naked, surrounded by the ruptured epidermis, dark brown; uredospores globose or elliptical with short spines and three germpores, brown, 20–25 × 18–23μ; teleutospores elliptical or globose, smooth, chestnut-brown, strongly thickened at apex, 22–30 × 18–25μ; pedicel long and firm, hyaline.

On *Indigofera Mexicana*, Oaxaca, October 23, 1899, no. 3722.

UROMYCES GALPHIMIAE Diet. & Holw.—Uredo on *G. Humboltiana*, Guadalajara, September 14, 1899, no. 3409.

UROMYCES VIGNAE Barclay ?—On *Vigna stroboliphora*, Guadalajara, September 15, 1899, no. 3424.

UROMYCES TRIFOLIAE (Hedw.) Lev.—On *Trifolium*, Pachuca, October 6, 1899, no. 3588.

UROMYCES GLOBOSUS Diet. & Holw.—On *Sapium biglandolosum*, Cuernavaca, September 28, 1899, no. 3517. This is the host plant of the original collection.

UROMYCES CALADII (Schw.) Farl.—On *Arisaema macrospathum*, Cuernavaca, September 29, 1899, no. 3522. The 1896 specimens are on this host, and not on *A. Dracontium*.

UROMYCES SOLANI Diet. & Holw.—On *S. appendiculatum*, Amecameca, October 31, 1899, no. 3761.

UROMYCES AEGOPOGINIS Diet. & Holw.—On *Aegopogon cenchroides*, Tizapan, Valley of Mexico, September 27, 1899, no. 3506.

Puccinia Berberidis-trifoliae Diet. & Holw., n. sp.—Spots brown, or blackish-purple; sori hypophyllous, firm, strongly pulvinate, black, about 1–3^{mm} in diameter, linear on the petioles; teleutospores brown, quite variable in form and size, elliptical, oblong or fusiform, rounded at apex, or conical, or often

prolonged into a point, mostly rounded at base, little constricted, 24–45×14–24μ, smooth, variously thickened at apex according to the form of the spore; pedicel rather longer than the spore, tinted, firm; one-celled teleutospores rather common.

On *Berberis trifolia*, Rio Hondo, near City of Mexico, October 4, 1899, no. 3570. The Aecidium of *Puccinia graminis* occurs on some of the leaves.

Puccinia Aniscanthii Diet. & Holw., n. sp.—Sori on both sides of the leaf, scattered, small; uredosori brown; teleutosori black, naked; uredospores elliptical or obovate, 22–28×18–22μ, light brown, with distant short spines, and two germ-pores; teleutospores elliptical, rounded at both ends, slightly constricted, 38–48×25–31μ, chestnut-brown, at the apex and often on the lower cell a cucullate or papilla-like light-colored thickening, verrucose; pedicel longer than the spore, hyaline, easily separating at the base, sometimes laterally inserted.

On *Anisacanthus*, probably *A. Wrightii*, near Acamboro, October 8, 1899, no. 3595. This species is much like *Puccinia Ruelliae-Bourgaei* Diet. & Holw., but that has almost all the pedicels laterally inserted, and the membrane is not thickened over the germ-pores. *Puccinia Blechi* Lagerheim appears to be very similar, but according to the description the teleutospores are differently colored, and also without the thickening over the germ-pores.

Puccinia Ruelliae-Bourgaei Diet. & Holw., n. sp.—Aecidia in irregular groups along the veins; cells of the pseudosporidia oblong; aecidiospores elliptical or globose, often angular, 25–38×20–26μ, yellowish, strongly verrucose, much thickened at apex; uredospores in these specimens few, with the teleutospores, brown, echinulate, 20–25μ; teleutosori hypophyllous on yellow spots, sparingly epiphyllous, scattered, 0.5–2^{mm} in diameter, black, pulverulent, naked; teleutospores elliptical, rounded at both ends, not at all or only slightly constricted, 35–41×27–32μ, dark chestnut brown, with large tubercles; pedicel as long or longer than the spore, hyaline, rough, inserted at one side.

On *Ruellia Bourgaei*, Chapala, September 20, 1899, no. 3471. Closely resembles *Puccinia lateripes* B. & R., but has much larger and darker teleutospores; the aecidiospores are also larger and remarkable for their strong apical thickening.

PUCCINIA HETEROSPORA B. & C.—On *Abutilon crispum*, Oaxaca, October 20, 1899, no. 3684; on *Anoda hastata*, near Tula, September 21, 1898, no. 3186; Cuernavaca, September 28, 1898, no. 3098; on *Anoda*, Patzcuaro, October 17, 1898, no. 3004; Orizaba, October 6, 1898, no. 3194; Chapala, September 22, 1899, no. 3477; on *Anoda acèrifolia*, Oaxaca, October 18, 1899, no. 3656; Cuautla, October 12, 1898, no. 3044; on *Sida Holwayi*, Cuautla, October 12, 1898, no. 3043.

PUCCINIA GALII (Pers.).—On *Galium uncinulatum* var. *obstipum*, Oaxaca, October 18, 1899, no. 3654.

PUCCINIA SEYMERIAE Burrill.—On *Seymeria virgata*, Oaxaca, October 22, 1899, no. 3721.

PUCCINIA PITCAIRNIAE Lagerh.—On *Pitcairnia Palmeri*, Chapala, September 1899, no. A; Uruapam, October 11, 1899, no. 3619. These two specimens are not exactly alike, the latter having somewhat smaller more regular spores less thickened at apex.

PUCCINIA MENTHAE Pers.—On *Monarda?*, Jalapa, October 3, 1898, no. 3211.

PUCCINIA PHILIBERTIAE E. & E.—Tizapan, Valley of Meixco, October 28, 1899, no. 3749, on *Metalstelma angustifolium*.

Puccinia Marsdeniae Diet. & Holw., n. sp.—Sori on yellow or brownish spots, medium-sized or small; uredosori scattered, cinnamon-brown, on both sides of the leaves; uredospores broadly elliptical, almost globose, 28–33×25–29μ, light brown; epispore thick, with widely separated short spines and numerous germ-pores; teleutosori epiphyllous, scattered, naked, black, pulverulent; teleutospores elliptical, rounded at both ends, very little constricted, 33–45×28–32μ, dark chestnut-brown, with large tubercles; pedicel up to 75μ long, easily breaking off at the base, often inserted at the side of the spore.

On *Marsdenia Mexicana*, Cuernavaca, September 29, 1899, no. 3529.

PUCCINIA XANTHII Schw.—On *Xanthium*, Chapala, September 17, 1899, no. 3440; Cuautla, October 12, 1898, no. 3042; Oaxaca, October 17, 1899, no. 3644; Cuernavaca, September 28, 1899, no. 3516; on *Zinnia tenuiflora*, Chapala, September 17, 1899, no. 3441; Oaxaca, October 17, 1899, no. 3646.

PUCCINIA KUHNIAE Schw.—On *Barroetea sabuligera*, Aguas Calientes, September 12, 1899, no. 3400.

Puccinia Oaxacana Diet. & Holw. n. sp.—Sori hypophyllous, small, scattered, brown; uredospores elliptical or ovate, 23–29×23μ, with echinulate epispore; teleutospores oblong or elliptical, rounded at both ends or narrowed to the base, little constricted, 31–50×18–25μ, smooth, pale brown, slightly thickened at apex, germinating at once; pedicel the length of the spore or a little longer.

On *Baccharis hirtella* DC., Oaxaca, October 18, 1899, no. 3673. *Aecidium fragile*, n. sp., occurs with this, but it is doubtful whether it is a stage of the Puccinia.

Puccinia Baccharidis-multiflorae Diet. & Holw., n. sp.—Sori hypophyllous, small, scattered; uredosori light chestnut-brown; uredospores obovate, 32–42×22–28μ, yellowish-brown, echinulate, apex with a cucullate thickening (up to 7μ) and with 3 germ-pores, which are covered with a convex hyaline thickening; teleutosori dark brown; teleutospores oblong, apex rounded or conical, mostly narrowed to the base, somewhat constricted, 38–60×21–30μ; epispore smooth, yellowish-brown, apex strongly thickened, and mostly somewhat paler; pedicel short, or up to 60μ long, hyaline, rather fragile. The spores germinate soon after maturity.

On *Baccaris multiflora*, Amecameca, October 31, 1899, no. 3757.

CAEOMA PUNCTATO-STRIATUM Diet. & Neg.—On *Baccharis*, Guadalajara, September 16, 1899, no. 3435, with *Puccinia Baccharidis*, Diet & Holw.

PUCCINIA BACCHARIDIS Diet & Holw.—On *Baccharis*, Patzcuaro, October 17, 1898, no. 3003; Guadalajara, September 16, 1899, no. 3435.

Puccinia Baccharidis-hirtellae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, punctiform, pulvinate, chestnut-brown; uredospores (mixed with the teleutospores) elliptical to globose, or obovate, 22–27×19–25μ, with a thin light brown echinulate epispore; teleutospores elliptical; rounded at both ends, slightly constricted, 32–46×20–30μ; epispore yellowish-brown, slightly or not at all thickened at apex, finely punctate; pedicel long, thin, hyaline.

On *Baccharis hirtella*, Amecameca, October 31, 1899, no. 3756.

Puccinia subglobosa Diet. & Holw., n. sp.—Sori on both sides of the leaves, particularly on the under side, scattered, punctiform, naked; uredosori chestnut-brown; teleutosori black, pulverulent; uredospores elliptical or obovate, sometimes almost globose, 18–25 × 17–20 μ brown, with short spines; teleutospores broadly ellipsoidal, often almost globose, rounded at both ends, not at all or only slightly constricted, apical thickening slight, smooth, dark chestnut-brown, 29–38 × 24–29 μ; pedicel hyaline, easily breaking from the host plant.

On *Viguiera Palmeri*, Chapala, September 23, 1899, no. 3488.

Puccinia praemorsa Diet. & Holw., n. sp.—Sori on the under side of brown roundish spots, which are somewhat depressed, solitary, medium-sized, dark brown, pulvinate, mostly made up of several small sori which have crowded together; teleutospores oblong-clavate, apex truncate, conical, or very irregular, narrowed at the base, somewhat constricted, 40–73 μ long, upper cell 15–30 μ wide, smooth, brown, thickened at apex; pedicel short, firm, brownish. The spores germinate, at least in part, as soon as mature.

On *Brickellia veronicaefolia*, Oaxaca, October 20, 1899, no. 3686. This is like *Puccinia Asteris*, but differs in several particulars.

Puccinia inanipes Diet. & Holw., n. sp.—Sori on both sides of the leaf, particularly on the upper, scattered, punctiform; uredosori brown; uredospores elliptical, rounded at both ends and when dry both ends depressed, scarcely constricted, apex with a very slight cucullate thickening, smooth, dark chestnut-brown, 34–42 × 28–31 μ, with long hyaline hollow pedicels which easily break from the host plant. For correction see p 422 vol XXXI

On *Eupatorium brevipes*, Oaxaca, October 18, 1899, no. 3677.

Puccinia espinosarum Diet. & Holw., n. sp.—Sori on both sides of the leaf, scattered, small or medium sized, naked; uredosori brown; uredospores ovate, epispore light brown, with short spines, 30–36 × 20–23 μ; teleutosori black; teleutospores broadly elliptical, rounded at both ends, apex with a slight cucullate

thickening, smooth, dark chestnut-brown, 40–50×32–36 μ; pedicel long (up to 125 μ), 10 μ thick, hollow at the base only, easily breaking from the leaf.

On *Eupatorium espinosarum*, Oaxaca, October 17, 1899, no. 3651.

PUCCINIA VIGUIERAE Peck.—On *V. picta*, near Tula, September 20, 1898, no. 3136; on *V. excelsa*, Rio Hondo cañon, near City of Mexico, September 22, 1898, no. 3160; City of Mexico, October 9, 1898; no. 3039; on *Gymnolomia Ghiesbreghtii*, Oaxaca, October 21, 1899, no. 3700; on *Viguiera*, Toluca, September 20, 1898, no. 3178; on *Gymnolomia subflexuosa*, Oaxaca, October 17, 1899, no. 3645; on *Verbesina trilobata*, Oaxaca, October 24, 1899, no. 3731; on *Verbesina virgata*, Rio Hondo cañon, near City of Mexico, October 30, 1899, no. 3751; on *Verbesina montanifolia*, Patzcuaro, October 10, 1899, no. 3604; on *Viguiera*, Chapala, September 20, 1899, no. 3469; on *Calea Zacatechichi* var. *rugosa*, Cuernavaca, September 30, 1899, no. 3534; September 28, 1899, no. 3512; on *Calea hypoleuca*, Oaxaca, October 17, 1899, no. 3648.

Puccinia ferox Diet. & Holw., n. sp.—Sori pulverulent, large, irregular, brown, attacking the upper leaves and occasionally the flowers, often destroying the plants, the leaves being much thickened and deformed and often entirely covered with the spores on both sides; teleutospores rounded at both ends, strongly constricted, with epispore uniform in thickness, pale brown, finely verrucose, 33–43×20–26 μ; pedicel short, fragile. The spores germinate at once.

On *Verbesina diversifolia*, Oaxaca, October 21, 1899, no. 3704. A very destructive species.

Puccinia Electrae Diet. & Holw., n. sp.—Sori on various colored spots on the upper side of the leaf, less numerous on the lower side, small, scattered; uredosori dark brown; uredospores obovate or elliptical, 28–35×21–25 μ, echinulate, brown; teleutosori naked, black; teleutospores elliptical, rounded at both ends, scarcely constricted, verrucose, apex not thickened, 36–48×24–31 μ; pedicel long, hyaline, or next the spore somewhat tinted, easily separating at the base from the host plant.

On *Electra Galeottii*, Oaxaca, October 18, 1899, no. 3664.

Puccinia Desmanthodii Diet. & Holw., n. sp.—Sori on the under side of large irregularly limited violet or yellow spots, small, but closely crowded into large groups in a kind of stroma formed of dark brown firm united paraphyses; teleutospores oblong or mostly fusiform, narrowed to both ends or truncate at apex, not at all or only slightly constricted, 40–60 × 10–17 μ, smooth, thickening at apex conical or cucullate, light brown; pedicel short or up to 40 μ long, firm, tinted.

On *Desmanthodium ovatum*, Oaxaca, October 18, 1899, no. 3665. Aecidia occur on some of the leaves but are too old to describe.

Puccinia Iostephanes Diet. & Holw., n. sp.—Sori mostly epiphyllous on small purple spots, less numerous on the under side of the leaf, scattered, black; teleutospores elliptical, rounded at both ends, scarcely constricted, chestnut-brown, verrucose, a light-colored cucullate thickening at the apex and on the side of the lower cell, 37–50 × 25–35 μ; pedicel long, hyaline, easily breaking at the base from the host plant, often laterally inserted.

On *Iostephane heterophylla?* Cuernavaca, September 30, 1899, no. 3543; on *Viguiera dentata*, Oaxaca, October 21, 1899, no. 3543, and October 25, 1899, no. 3744. Type is on no. 3543, the host being an Iostephane which is probably *I. heterophylla*, although it differs somewhat from other Mexican specimens.

Puccinia Guardiolae Diet. & Holw., n. sp.—Sori on purple spots, hypophyllous, rarely single sori epiphyllous, punctiform, scattered; uredosori dark brown; uredospores nearly globose, elliptical or obovate, 24–32 × 22–25 μ, dark brown, echinulate, with two germ-pores; teleutosori blackish, strongly convex, firm, small; teleutospores clavate, rounded at apex, or more rarely truncate, with a hyaline cucullate thickening, narrowed to the base or rounded, constricted, 45–60 × 18–25 μ, smooth, pale brown, germinating at once, whitening the sori; pedicel hyaline, firm, mostly shorter than the spore.

On *Guardiola Mexicana*, Cuernavaca, September 28, 1899, no. 3513.

Puccinia conjuncta Diet. & Holw., n. sp.—Sori epiphyllous, a few scattered ones epiphyllous, of medium size, except on the petioles and stems, where they break through the epidermis in large patches, pulverulent, dark brown; teleutospores strongly constricted, of two almost globose cells, 34–45×22–28μ, brown, echinulate, apex with a slight cucullate thickening; pedicel short, deciduous.

On *Lippia Pringlei*, Oaxaca, October 23, 1899, no. 3719B. Collected at about 10,000 feet, where there were no specimens of *Uredo Lippiae* D. & H. to be found. The latter occurred at about 6000 feet.

Puccinia Coulterophyti Diet. & Holw., n. sp.—Spots yellow or wanting; sori hypophyllous, small, scattered; uredosori light ochre color; uredospores obovate, 29–36×22–29μ; epispore hyaline, apex very strongly thickened, covered with distant, globose warts; teleutosori blackish-brown, naked, pulverulent; teleutospores long elliptical or irregular, rounded at both ends, scarcely constricted, 33–50×23–30μ; epispore chestnut-brown, verrucose, sometimes irregularly rugose; pedicel deciduous. One-celled teleutospores are not uncommon.

On *Coulterophytum laxum* Rob., Chapala, September 19, no. 3463; Uruapam, October 11, no. 3621. These hosts were determined for me at the Gray Herbarium. The leaflets differ, however, the former being smooth, while the latter are densely white-tomentose.

Uredo Lippiae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, dark brown, pulverulent; uredospores globose or broadly elliptical, 25–32×25–28μ; epispore dark brown, closely echinulate, to 3μ thick, with two germ pores. Hyaline ampullaceous paraphyses are found in the sori.

On *Lippia Pringlei*, Oaxaca, October 23, 1899, no. 3719. Collected at about 6000 feet. No trace of *Puccinia conjuncta* D. &. H. could be found at this elevation.

UREDO ARBUTI Diet. & Holw.—On *Arbutus diversiflora*, Oaxaca, October 18, 1899, no. 3662.

RAVENELIA EPIPHYLLA Schw.—On *Brongniartia*, Guadalajara, September

14, 1899 no. 3415; on *Tephrosia Talpa*, Oaxaca, October 19, 1899, no. 3679.

RAVENELIA INDICA Berk.—On *Cassia Absus*, Tequila, September 29, 1893, *C. G. Pringle*.

RAVENELIA BRONGNIARTIAE Diet. & Holw.—On *B. sericea*, Oaxaca, October 18, 1899, no. 3663; on *Brongniartia*, Cuernavaca, September 28, 1898, nos. 3170 and 3022; September 29, 1899, no. 3519; on *B. intermedia*, Tizapan, Valley of Mexico, September 27, 1899, no. 3504½.

RAVENELIA INDIGOFERAE Tranzschel.—On *Indigofera Palmeri*, Oaxaca, October 19, 1899, no. 3682, forming swellings on the stems, and apparently quite destructive; on *Indigofera Cuernavacana*, Cuernavaca, September 22, 1898, no. 3120.

Ravenelia spinulosa Diet. & Holw., n. sp.—Sori on both sides of the leaf, breaking forth from beneath the epidermis, of irregular shape and size; uredosori ochre-colored; uredospores elliptical or almost globose, 18–23×16–19μ, light brown, with short spines, germ pores numerous, paraphyses sparingly intermixed; teleutosori black, heads hemispherical, 75–110μ in diameter, with 7–9 spores in cross-section, chestnut-brown, with numerous globose hyaline cysts on the under side; spores 11–17μ broad, one-celled, each with a long (up to 8μ) pale brown point at the apex.

On *Cassia multiflora*, Oaxaca, October 18, 1899, no. 3675. This species is much like the African *R. Stuhmanni* P. Henn., but has smaller uredospores.

PUCCINIOSIRA PALLIDULA (Speg.) Lagerh. (*P. triumfetta* Lagerh.).—On malvaceous plant, Jalapa, April 22, 1899, *C. G. Pringle*. Is probably on *Triumfetta* sp.

PUCCINIOSIRA BRICKELLIAE Diet. & Holw.—On *Brickellia tomentella*, Amecameca, October 31, 1899, no. 3767. These specimens show that the fungus also occurs on the under side of the leaves in various sized groups, sometimes annular, or elongated along the veins, and that the spores are not smooth, as originally described, but finely verrucose.

Endophyllum singulare Diet. & Holw., n. sp.—Sori covering large areas of the stems and leaves, with pseudosporidia strongly developed, conical, up to 2^{mm} long, irregularly splitting; spores ochre-colored in mass, elliptical or oblong, not rarely pointed at

apex, 40–55 × 24–30μ; epispore pale brown, strongly thickened at apex, closely verrucose.

On ericaceous plant, Jalisco, *Marcus E. Jones.*

Stichospora Mentzeliae Diet. & Holw., n. sp.—Sori hypophyllous, scattered, small; uredosori orange-yellow when fresh, white when dry; uredospores formed in short chains, 20–28 × 20–24μ; epispore verrucose, hyaline; teleutosori waxy, blood-red, 100–120μ high; teleutospores formed in a few series, one over the other, cylindrical clavate or elliptical, 24–45 × 14–20μ, at first one-celled, shortly before germination divided by vertical septa into four cells; epispore of the upper spore of each series with a hyaline thickening (up to 8μ); sporidia elliptical, often narrowed to one end, 15 × 10–13μ.

On *Mentzelia hispida*, Chapala, September 18, 1899, no. 3452.

Coleosporium Verbesinae Diet. & Holw., n. sp.—Sori scattered or in irregular groups, hypophyllous; uredosori golden-yellow; teleutosori bright red; uredospores elliptical to globose, 26–33 × 23–26μ, with colorless verrucose epispore; teleutospores cylindrical, up to 130μ long, 12 × 18μ thick, strongly thickened at apex.

On *Verbesina virgata*, with *Puccinia Viguierae*, Rio Hondo cañon, near City of Mexico, October 30, 1899, no. 3751; on *Verbesina*, Cuernavaca, September 30, 1899, no. 3542.

Coleosporium paraphysatum Diet. & Holw., n. sp.—Sori hypophyllous, on yellow or chestnut-brown spots, small, scattered; uredospores long-elliptical to clavate, with sharply projecting warts, 26–43 × 17–24μ; teleutospores at first ellipsoidal and one-celled, at length cylindrical or clavate, and divided by horizontal septa into four cells, 45–65 × 17–22μ; in many teleutosori there were numerous filiform paraphyses.

On *Liabum discolor*, Chapala, September 23, 1899, no. 3483.

Coleosporium anceps Diet. & Howl., n. sp.—Uredosori punctate, scattered or in circular groups, hypophyllous, white when

dry; uredospores elliptical, oblong, or almost globose, 17–25×15–20μ, with long cylindrical tubercles; teleutosori hypophyllous, on yellow or brown dead spots, single, or often in annular or irregular groups, honey-colored, waxy; teleutospores cylindrical or clavate, 90μ long, 18–25μ wide, 4-celled; pedicel hollow, 60–70μ long; sporidia mostly cylindrical, 24–30×12–15μ.

On *Verbesina sphaerocephala*, Chapala, September 24, 1899, no. 3492, mostly Uredo, and September 25, 1899, no. 3501, only teleutospores.

DECORAH, IOWA.

OVULE AND EMBRYO OF POTAMOGETON NATANS.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XXVIII.

G. M. HOLFERTY.

(WITH PLATES II AND III AND ONE FIGURE)

THIS investigation was begun several years ago, and was continued as time permitted. Material from a number of stations in the vicinity of Chicago was collected, and other collections have been added. From this material about seven hundred slides of microtome sections have been prepared and studied. The work was done under the direction of Professor John M. Coulter and Dr. Charles J. Chamberlain.

MATERIAL AND METHODS.

The collections were made in June, July, and August. Those made in June show some young spikes still within the cone-shaped spathe, while others are just issuing from it. Early in July the flowers open and pollination is effected, while in August the seed comes to maturity.

The spikes were cut off with a sharp scalpel and dropped at once into the 1 per cent. solution of chrom-acetic acid. After remaining in the solution from 36 to 48 hours, the material was washed in warm water, and then allowed to remain in running tap water 20 to 24 hours. After imbedding in paraffin the material was cut on a Minot microtome, the sections being from 6–13μ in thickness.

Combination stains were used for all work, cyanin and erythrosin proving most satisfactory, particularly for sporogenous tissues. The safranin gentian-violet orange G combination gave very satisfactory results for chromosomes and all phases of mitosis. The length of time sections should be left in each

stain became a matter of some experimentation. In general, 30 to 40 minutes in cyanin and 30 to 40 seconds in erythrosin gave the bests results. The use of turpentine between absolute alcohol and xylol was found to be of decided advantage in many cases.

FLOWERS AND SPIKES.

The flower consists of four similar cup-shaped sepals, four opposite stamens, and four alternate carpels. In early stages the sepals completely overlap the other organs, but later they spread sufficiently to allow the protruding styles to expose the stigmas for pollination. Each stamen branches, bearing an anther on each branch. The anthers are biloculate, and hence the group of four carpels is surrounded by sixteen pollen-sacs. The flowers are nearly sessile on the vertical spike, alternating in such a way that the spiral arrangement is clearly seen (*fig. 1*).

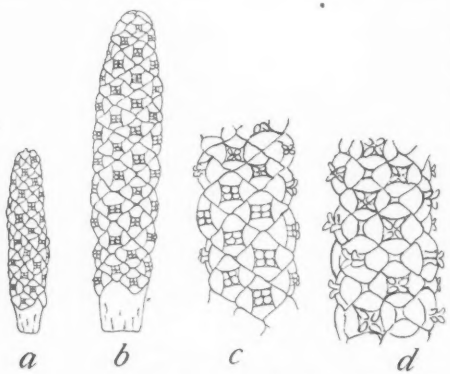


FIG. 1.—Illustrations of spikes: *a*, × ⅔ size; *b*, × ⅓; *c*, × ⅔; *d*, × 2.

From these spikes longitudinal and transverse sections were cut. It can be seen that the first and last longitudinal sections from such a cylindrical spike would give cross-sections of stigmas, styles, and ovaries; while those cut from the center would give two rows of longitudinal sections. Cross-sections of the spike would of course give longitudinal sections of ovaries, styles, and stigmas, but in a plane at right angles to the longitudinal sections mentioned above.

THE OVULE.

The embryo sac is much more deep-seated than in many other plants, occurring in the center of the nucellus, and surrounded

on all sides by a mass of tissue from five to eight cells in depth. This deep-seated position may bring added protection of some sort, or it may have no such significance. In the earliest stages of the nucellus no differentiation of cells can be distinguished. Its growth appears to be due almost entirely to divisions of nucellar tissue other than epidermal, since after the formation of the epidermis no layers were observed cut from it by periclinal walls. In fact, the occurrence of periclinal walls in the epidermis is exceedingly rare.

The archesporial cell and its two daughter cells.—Longitudinal sections of the nucellus, about the time the primordium of the inner integument makes its appearance, show a single hypodermal cell having archesporial characters. This cell is larger than the others and has a larger nucleus, and its protoplasm is usually less dense (*fig. 1*). When this hypodermal cell is barely distinguishable from the surrounding tissue, it divides by a periclinal wall. The outer cell is the so-called "tapetal cell" (*figs. 2, 3*), from the progeny of which an extensive region of sterile tissue is subsequently formed. The inner cell is the primary sporogenous cell or megaspore mother cell, its sporogenous character being plainly shown by the rapid changes which soon take place in both its nucleus and cytoplasm.

The sterile tissue.—The subsequent history of the tapetal cell is as follows. The increase in size is followed at once by a periclinal division (*fig. 4*), and this by an anticlinal wall (*fig. 5*). Doubtless an anticlinal wall follows in each of these cells, making a plate of four cells lying next to the epidermis. Wiegand[1] says that the anticlinal walls may precede or follow the periclinals, usually preceding, but this was not verified in *P. natans*. Anticlinal walls now follow in the second layer, thus completing a two-layered tapetum. In *fig. 7* a three-layered tapetum is shown; in *fig. 13* one that is five-layered. The process continues until in some cases eight layers lie between the embryo sac and the epidermal layer. As mentioned before, the embryo sac now lies in the very heart of the nucellus.

[1] WIEGAND KARL M.: The development of the embryo sac in some monocotyledonous plants. BOT. GAZ. **30**: 25–47. *pls. 6–7.* 1900.

The primary sporogenous cell.—At the same time the primary sporogenous cell is undergoing important changes. It increases very much in size, its contents becoming less and less dense, until in some cases vacuoles make their appearance (*fig. 6*). The nucleus also increases in size, and is often surrounded by an area of hyaline cytoplasm (kinoplasm), while radiating strands of granular protoplasm extend from the nucleolus to the periphery of nucleus (*figs. 2, 3*). The chromatin of the nucleus now collects in a closely compacted mass, with a dense non-granular nucleolus by its side (*figs. 4, 5, 6*), the cell having passed into the synapsis stage so characteristic of mother cells.

That the development of the primary sporogenous cell has been simultaneous with the formation of tapetal tissue is shown by the fact that in many cases the former cell has been found in early synapsis with only a two-layered tapetum (*fig. 4*). As the nucleus of the mother cell passes to the spirem stage, the chromatin threads are usually more on one side than on the other. The nucleoli never appeared granular, though often one to several very large granules or black grains could be seen. The cytoplasm was never uniform in appearance, at times having a reticulated appearance (*fig. 5*), and again a stringy appearance (*fig. 6*).

It may be stated that if the manipulation of the stains has been fortunate, one finds in all phases of synapsis an excellent illustration of the value of cyanin and erythrosin as differential stains, the chromatin being always a deep red and the nucleolus a deep blue. There was in the case of Potamogeton no difference in the way in which the stains were taken up by nuclei of the megaspore and microspore mother cells, thousands of the latter showing the highly erythrophilous chromatin and the highly cyanophilous nucleoli seen in the former.

Development of potential megaspores.—It was some time before any positive evidence of an axial row could be found; but the presence of a cap of densely staining protoplasm at the micropylar end of the sac was a strong indication of its presence.

Wiegand[2] demonstrated a two-celled row for *P. foliosus*, but found the fate of the two cells somewhat unusual. He says, "the first division of the archesporial cell is immediately followed by a second nuclear division in each of the daughter cells, but without the formation of a wall between the two nuclei. The upper of these two cells soon perishes, while the lower goes on through various phases forming at last the complete embryo sac."

In *P. natans* some irregularity appears in the number of cells of the axial row, but it is always more than two, brought about by the division of one or both daughter cells of the primary sporogenous cell. The early stages of the division of the sporogenous cell are shown in *figs. 4–7*. In the stage shown in *fig. 8*, the chromosomes have passed to the poles, the spindle fibers are still intact, and the cell plate is clearly marked. A spindle is also formed in each daughter cell (*fig. 9*). It is at this point that the irregularity mentioned above appears. That a spindle is not always formed in each cell may be inferred from *fig. 11*, where the lower cell shows by its size, age, and nucleus that it is the functioning megaspore. The middle cell, its sister cell, is being resorbed along with the upper cell. The spindle shown in *fig. 10* indicates that the two resulting potential megaspores will lie side by side. The preparations referred to thus far do not show any completed four-celled axial row, but they do show several three-celled rows, with spindles to indicate four potential megaspores. The spindle in the upper cell of the axial row, in both cases shown, is transverse rather than longitudinal.

The germination of the megaspore.—The divisions leading to the ante-fertilization stage of the gametophyte appeared perfectly regular and normal, although Wiegand[3] states that in *P. pauciflorus* both egg-apparatus and antipodals were somewhat abnormal. He says, "although the normal number of cells in each was present, they were formed irregularly. The polar nucleus and

[2] WIEGAND, KARL M.: *loc. cit.* 32.

[3] WIEGAND, KARL M.: Notes on the embryology of Potamogeton. BOT. GAZ. 25:116–117. 1888.

first and second synergids seem to have been cut off successively from the mother nucleus of the egg. The synergids disappear almost immediately. A similar irregularity was found in the antipodals." This could not be verified in *P. natans*, in which the process seems quite normal (*figs. 13, 14, 17*). At this time there is considerable plasmolysis even when great care is taken in the fixing and subsequent processes (*figs. 15, 16, 17*). In *fig. 14* traces of the first spindle of the megaspore can still be seen connecting the recently formed daughter nuclei, but there is no trace of a wall. By the growth of the sac the antipodals are left in a small pocket, and are of short duration (*figs. 16, 17*); but no traces of a wall shutting them off from the rest of the sac at any time could be found. Nor could a wall be found cutting off the egg-apparatus from the opposite end of the sac. The polar nuclei never meet in the center of the sac, but always nearer the antipodal end (*figs. 16, 17*). The endosperm develops as a parietal layer of cytoplasm in which free nuclei are imbedded, and no walls were observed in the most advanced stages studied (*figs. 19, 21d*).

THE EMBRYO.

The first division of the oospore is transverse, resulting in a large vesicular suspensor cell and the first cell of the embryo proper (*fig. 18*). The three-celled embryo shown (*fig. 19*) has probably resulted from the division of the embryo cell. The single suspensor cell becomes remarkably large and vesicular, and its nucleus and nucleolus correspond in size. The first division of the terminal cell in the row of three is longitudinal (*fig. 20*), and this is followed by a second longitudinal division at right angles to the first (*fig. 21*). This quadrant stage is also shown in transverse section in *fig. 21d*. Further views of the embryo at this period are shown in *figs. 21a–21d*, which are consecutive transverse sections from such an embryo as that shown in *fig. 21*, in which figure the points at which the sections are made are lettered *a*, *b*, *c*, *d*. It is seen from the sections that the young embryo is cylindrical rather than flattened.

In two or three cases a very large nucleus was found near the antipodal end of the embryo sac, the embryo being in the stage just described. Its origin could not be determined, but it seems reasonable to consider it a derivative of the primary endosperm nucleus, and possibly the lower nucleus of the first division, as in *Sagittaria*[4] and *Potamogeton pauciflorus*.[5]

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES II AND III.

FIG. 1. Micropylar end of nucellus, showing the archesporial cell.

FIG. 2. Primary sporogenous and tapetal cells.

FIG. 3. The same at a later stage; nucleus with radiating strands of protoplasm, and surrounded by a hyaline area.

FIG. 4. Tip of a young nucellus; inner integument and primordium of outer integument; sporogenous cell with nucleus in early synapsis stage; chromatin massed, dense (deeply erythophilous); nucleolus non-granular (deeply cyanophilous); two-layered tapetum.

FIG. 5. Primary sporogenous cell; nucleus in synapsis; a two-layered tapetum with an anticlinal wall recently formed.

FIG. 6. Same with two-layered tapetum; nucleus in synapsis.

FIG. 7. Same with three-layered tapetum.

FIG. 8. Same with spindle and cell-plate; epidermis with double layer but taking no part in tapetal structure.

FIG. 9. Same with two spindles; upper one nearly transverse; beginning of axial row.

FIG. 10. Axial row showing two potential megaspores, and the upper daughter cell with a spindle.

FIG. 11. Functioning megaspore more advanced, but no sign of further division in either middle or upper cells.

FIG. 12. Functioning megaspore resorbing the potential megaspores.

FIG. 13. Embryo sac after the first division; daughter nuclei widely separated, with large vacuole between them; six-layered tapetum.

FIG. 14. Embryo sac after second division; remnants of the spindle between the nuclei at antipodal end of sac; eight-layered tapetum not all shown.

FIG. 15. Micropylar end of embryo sac, showing cells of the egg-apparatus; from section adjacent to *fig. 16*.

[4] SCHAFFNER, JOHN H.: Contribution to the life history of *Sagittaria variabilis*. BOT. GAZ. **23**: 252–273. *pls. 20–26*. 1897.

[5] WIEGAND, KARL M.: BOT. GAZ. **25**: 117. 1898.

FIG. 16. Antipodal end of embryo sac; antipodals in pocket, and polar nuclei meeting in lower end of sac; from section adjacent to *fig. 15*.

Fig. 17. Embryo sac after third division, showing the eight-celled stage; synergids with vacuoles, egg cell beneath; antipodals in pocket, two with nuclei, remnant only of the third one; polar nuclei meeting below the center.

FIG. 18. A two-celled embryo, showing the large vesicular cell and first cell of embryo proper.

FIG. 19. A three-celled embryo imbedded in endosperm and suspended from the large vesicular cell; endosperm of free nuclei embedded in cytoplasm; each nucleus with two nucleoli.

FIG. 20. A four-celled embryo; the end cell divided longitudinally; very large vesicular cell with correspondingly large nucleus and nucleolus.

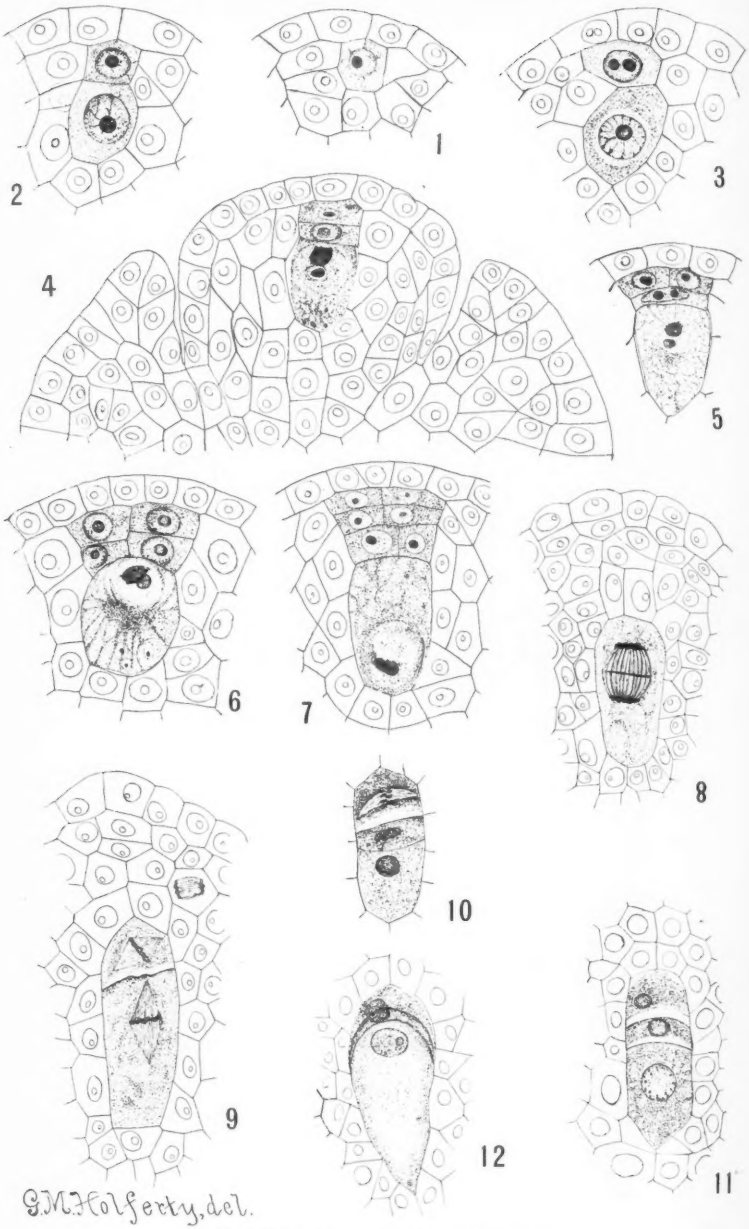
FIG. 21. An eight-celled embryo; end-cell divided into four cells; very large vesicular cell; letters denote points of cross-sections shown in following figures.

FIG. 21*d*. Cross-section of end cell through *d* in *fig. 21*.

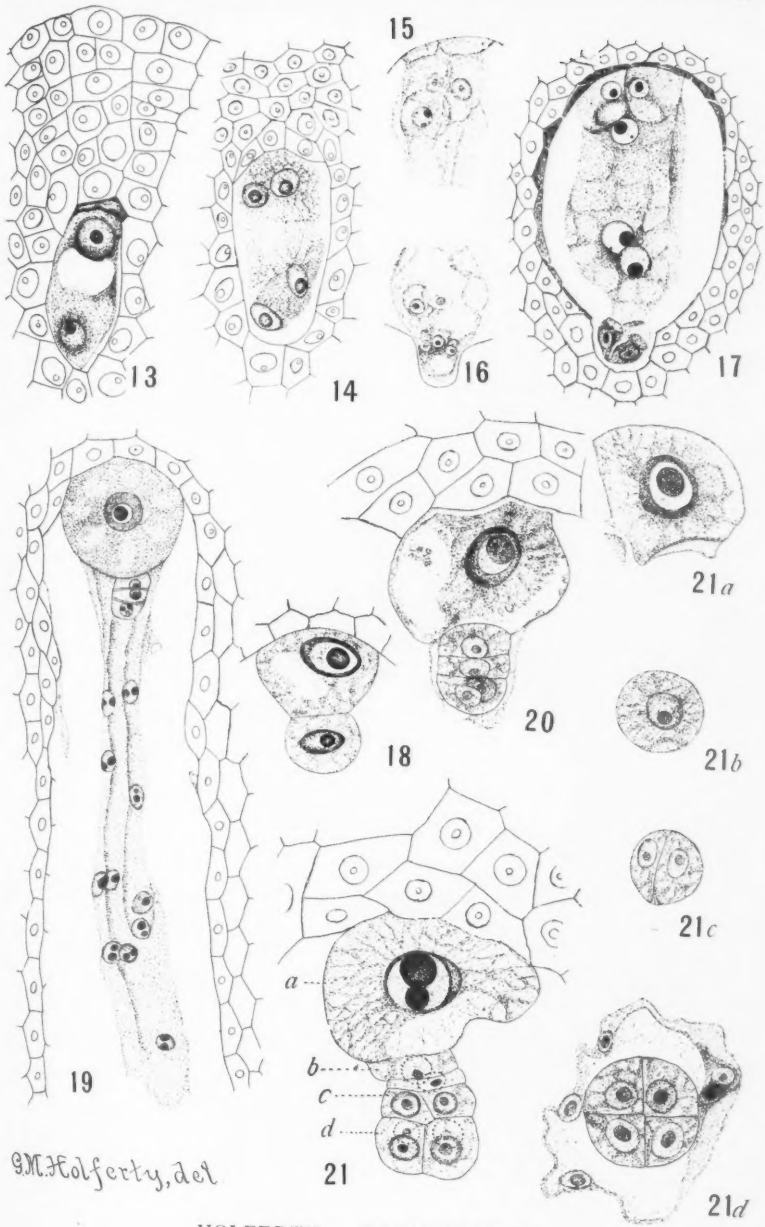
FIG. 21*c*. Cross-section through *c* in *fig. 21*.

FIG. 21*b*. Cross-section through *b* in *fig. 21*.

FIG. 21*a*. Cross-section through *a* in *fig. 21*.



HOLFERTY on POTAMOGETON



HOLFERTY on POTAMOGETON

BRIEFER ARTICLES.

FERN VARIATION IN GREAT BRITAIN.

Up to a comparatively recent date, the departures from the normal type of ferns which were found growing wild under perfectly natural conditions received little or no attention from professional botanists, but were simply dubbed "monstrosities" and left to amateurs to collect, cultivate, and observe. Eventually, however, the discovery that these "sports" did not always merely involve a superficial change of form, but also that this change was in some cases correlated with hitherto unknown modifications and abridgments of the normal life cycle, led to a greater interest being taken, with the result that theories as to the origin of alternation of generations were seriously affected. Before these investigations and discoveries, it was assumed that the life cycle was necessarily spore, prothallus, fertilized egg, and finally the sporophyte or fern proper. Apogamy, however, discovered by Professor Farlow, eliminated the sexual act, a vascular structure originating in the prothallus which resulted in an asexual bud, whence at once arose the sporophyte, the life cycle then being spore, prothallus, sporophyte. This, though first remarked in a normal *Pteris cretica*, was subsequently found by DeBary to occur with seeming constancy in an abnormal tasselled form of Lastrea (*L. pseudo-mas cristata*) and several other species normal and abnormal. The next discovery was that of soral apospory by the writer, on a form of *Athyrium filix-foemina*, which shortened the life cycle in another way altogether, by eliminating the spore, masses of prothalli being produced, as Professor F. O. Bower subsequently ascertained, from the stalks of aborted sporangia, on the ordinary soral sites.[1] Here the life cycle runs thus, sporophyte, sorus, prothallus, fertilized egg, sporophyte. No sooner was this phenomenon announced than Mr. G. B. Wollaston reported the still more remarkable case of apical apospory in a form of *Polystichum angulare* (*P. ang. pulcherrimum*), in which the abnormally long sickle-shaped pinnules

[1] Druery, C. T.: Jour. Linn. Soc. **21**: 354. 1884; **22**: 427–440. 1885. Bower, F. O.: Trans. Linn. Soc. **2**: 301–326. 1887.

had their terminal and segmental apices dilated into prothalli, which when layered ran the normal course, with the exception that resulting plants were invariably defective and depauperate. Here the sorus is eliminated, and the prothalli are produced altogether independently of the usual reproductive sites, by a modification of the tissue of the sporophyte. Several quite independent finds of the *pulcherrimum* type existed, and in every case apical apospory was found to be correlated with it, and furthermore soral apospory existed on the fertile fronds. The modifications of the life cycle, however, were not even yet exhausted, for curiously enough a sporeling of the apogamous variety of Lastrea above mentioned was found by the writer to bear a well developed prothallus at the tip of its first frond, and the second and third bore prothalli, even profusely, on their surfaces, a sort of prothallic rash as it were.[2] These produced a brood of plantlets, but one and all lost this aposporous character and assumed the merely crested type of the parent as their later fronds arose. Here as we have apogamy and apospory associated, the life cycle dwindles down to sporophyte, prothallus, sporophyte, the shortest possible cut except the bulbils on the fronds of viviparous ferns, which have no intermediate stage at all. Subsequently, the writer found both soral and apical apospory on another variety of Athyrium, and apical on a fimbriate form of Scolopendrium.[3] Curiously enough, subsequent to the discovery of the aposporous Lastrea, a sporeling of the same parentage originated in Mr. Cropper's collection, which was and is profusely prothalliferous from all apices, the smallest piece of frond forming a mass of prothalli when layered, which creeps about Marchantia-like and yields a perennial crop of typical plants. Finally, in this connection, Professor Farlow found an aposporous (soral) type of *Pteris aquilina*. Subsequently, at Professor F. O. Bower's suggestion, Mr. W. H. Lang commenced a series of investigations in connection with the prothalli produced from spores of abnormal varieties, and thereby practically completed the series of abnormal modifications of the life cycle, by finding in more than one species prothalli bearing developed sporangia and spores,[4] thus cutting out the sporophyte, and reducing the life cycle to spore, prothallus, spore, an absolute minimum. I must refer to Mr. Lang's

[2] DRUERY, C. T.: Jour. Linn. Soc. **29**: 480–482. 1892.

[3] DRUERY, C. T.: Jour. Linn. Soc. **30**: 281–284. 1892.

[4] LANG, W. H.: Proc. Roy. Soc. **63**: 56–61. Phil. Trans. Roy. Soc. Ser. B. **190**: 187–238. 1898

papers for the most interesting details of these and other vagaries, and will merely add that on one and the same prothallus several different modes of reproduction were found, namely, asexual bulbils, some producing fronds and others merely roots; other prothalli budding out from the surface; and sporophytes sexually developed; all these on prothalli which themselves were thick cylindrical fleshy masses instead of the normal flat cordate thallus, while archegonia, antheridia, and sporangia were indiscriminately dotted about among the other varied growths.

The above facts are cited merely as a prelude and justification for the suggestion that in the study of American species the varieties should have due attention and not be labeled "monstrosities," and ignored as they were in Great Britain for a very long period. The writer has repeatedly urged and urges once more that it is quite as much, if not more, in the direction of nature's exceptions that we should seek the key to many of her secrets. Certainly in the study of the abnormal fern types alluded to, a number of new and unexpected facts have cropped up, which largely modify previous ideas regarding fern reproduction, not one of the links in the normal life cycle being absolutely essential. Spore, prothallus, egg, sporophyte, have all in turn been shown to be superfluous, the fern in one shape or another reproducing itself without them.

As regards the great number of varietal forms which have originated in Great Britain, there is little doubt that it is due far more to the continued existence of a coterie of persistent variety hunters than to any predisposing elements in the environment. The traveling botanist is rarely a variety hunter, but a species hunter, hence he does not in a habitat full of known species examine them plant by plant, or scan them with a peculiarly trained eye, as would the hunter for sports. If he have such an eye and a taste for varieties, we have the evidence that "finds" will crop up abroad as well as at home. Witness Mr. George Brown, who found *Woodwardia radicans cristata*, two finely crested forms of *Lastrea dilatata*, and two tasseled forms of *Aspidium hemionitis* in the Azores; while the writer, hunting in all for about two hours recently in Fayal (Azores), found a clump of *Aspidium hemionitis* beautifully tasseled throughout, and a fine pendulous polydactylous variety of *Pteris aquilina* which lined the high road for fifty yards. This being so I would advocate variety hunting in the United States as a pursuit likely to reward its votaries not merely with very beautiful types for

their collections, but also with material well worthy scientific attention. Thanks to some short notes sent to the *Fern Bulletin*, I have received already fronds of a crested Athyrium found by a lady, and plants of *Denstaedtia punctilobula cristata* and *Phegopteris hexagonoptera truncata*, the latter found by Mr. W. R. Maxon on the Potomac, which have originated in the United States as wild sports, a proof that such sports exist. At the same time, however, I note that much stress is laid upon doubtful subvarieties, which a wider knowledge of marked ones would probably minimize considerably. In my own fern hunting expeditions I invariably come across subvarieties in which the cutting is more or less modified; but with the abundance of really marked types in mind, these are simply noted and left. As exemplifying this abundance the figures from Mr. G. I. Lowe's *British Ferns*, a descriptive list published in 1891, may be appropriately quoted.

	No. of vars.
Pteris aquilina	17
Adiantum capillus-Veneris	34
Asplenium adiantum nigrum	16
trichomanes	27
maximum	28
Athyrium filix-foemina	313
Scolopendrium vulgare	450
Polystichum aculeatum	34
angulare	394
Lastrea filix-mas	54
pseudo-mas	42
propinqua	28
montana (oreopteris)	77
dilatata and others	57
Polypodium vulgare	74
Other varieties of sundry species	214
Total	1859

Upon analysis it is found that 1119 of these were wild finds, without reckoning additional independent finds of forms too similar to differentiate. This list cannot be regarded as exhaustive, and we may safely reckon the distinct varieties at over 2000, and the wild finds at 1500. As a concrete example of what one man can do in a single district, Mr. J. Moly, of Langmoor in Dorset, is credited with no less than 600 distinct finds in that and adjoining counties. His near

neighbor, Dr. Wills at Chard, found several hundred more. The numbers, however, represent the outcome of many years of persistent search, which, however, could not have been exhaustive, as it is recorded that Mr. Patey, visiting Mr. Moly, found one of the finest of all types (*P. ang. plumosum* Patey) in Mr. Moly's own hedge, while Dr. Wills was indebted to a farm laborer for that unique fern *P. ac. pulcherrimum*, also found in a hedge close to his house, and thought to have a funny look about it by the finder. Finally as an inducement to fern hunting, we have the incontrovertible fact that many of these wild sports are far more beautiful than the normal forms, and as such constitute decorative foliage plants of highest merit.

A word may be added in reference to the soral bulbils, as these occurrences should afford good material for the morphological study of the sporangium. Professor Bowers' monograph on apospory and allied phenomena, already cited, gives some illustration of this, and the writer's previous paper[5] also alluded thereto. Since then, however, such soral bulbils have been recorded as occurring on *Adiantum capillus-Veneris* vars. *daphnites* and *imbricatum*, and on *Polypodium vulgare elegantissimum*, while most of the *superbum* section of plumose Athyria have inherited the capacity from the original wild Axminster find. In all these cases the bulbils are seated on the soral sites, and are usually accompanied by sporangia grading from imperfect and aborted ones to perfect ones with full complement of perfect spores which germinate freely and yield fairly typical plants. In the case of the Polypodium, such bulbils occur only on the most highly developed fronds, and on pinnules of extremely fine cutting, the terminals of which run out into nearly inch long lingual extensions, pointing I think to aposporal tendencies. The sori are massive and consist of filamentous processes some of which lengthen out into fronds, while others form perfect sporangia of normal golden yellow color. Here then do not appear those massive cellular growths which are found on the Athyria, but in time one bulbil gets the predominance and a little plant of several small fronds is developed. Unfortunately, neither my leisure nor my training permit me to investigate properly the transitional stages which must exist in cases like these, but I should be happy to provide material to any one who desires to follow up this line of research.—CHARLES T. DRUERY, 11 Shaa-road, Acton, London, W.

[5] Jour. Linn. Soc. **21**: 254. 1884.

NOTES OF TRAVEL. IV.

COFFEE GROWING IN BRAZIL AND THE GIANT JEQUITIBÁ TREES.

IT was the writer's pleasure to accompany Colonel Charles Page Bryan, American minister to Brazil, on a visit to São Paulo and one of its large coffee estates. Santos, the port of São Paulo, and therefore the greatest coffee port of the world, is connected by an excellent line of railway with the latter. São Paulo is a rapidly growing town of some 65,000 inhabitants and is surrounded by many square miles of plantations of Arabian coffee.

The geological and geographical commission of the state of São Paulo is situated here at the capitol, and Dr. Orville Derby, a graduate of Cornell, is its originator and present chief. Under Dr. Derby's direction a botanical department has been established and an economic botanic garden started, with Mr. Alberto Löfgren at its head, a competent and thoroughly enthusiastic Swedish botanist. Mr. Löfgren is assisted by a systematist, Mr. Gustavo Edwall, who has charge of the rapidly increasing herbarium, and also by a young Belgian gardener.

At Tremembé, an hour's ride by steam train from the city, is the young botanic garden, now with about four acres in cultivation and many more available, a small laboratory, cold frames, and a convenient house for orchids and other shade loving plants. In this garden Mr. Löfgren is planting native forage plants, fruit trees, and ornamentals, with the view of introducing them into Brazilian culture. As in all new countries, the field here for such work is quite open, and this garden, if properly supported, will be of great importance to the country.

The best varieties of East Indian mangoes, the southern varieties of alfalfa, and the best sorts of oranges are all quite unknown in this immense region that is so admirably suited to their cultivation, and to that of many other economic plants. The pioneer work of plant introduction has scarcely been begun in São Paulo, and will not make much progress until coffee ceases to be what wheat is in our prairie states, the one lucrative crop.

At the invitation of Dr. Eduardo Prado, owner of one of the largest coffee estates, as well as owner and editor of one of the prominent newspapers in Brazil, Minister Bryan and his party spent a day on the Bergõn coffee estate, some eight hours' ride by train from São

Paulo. To any one who has seen Ceylonese, Javanese, or even Hawaiian coffee plantations, the Brazilian method of culture will be in striking contrast, as no shade trees are employed. The sight of thousands of acres of any perennial plant is impressive, but a plantation of 770,000 trees of coffee, loaded with dark red berries, is really beautiful as well as impressive.

The Brazilian coffee soil is more like New Jersey red clay than any other American soils I know, but it breaks up into an impalpable powder and rises in brick-red clouds about the horses and wagons driving through the plantation, and stains every thing a bright red that is very difficult to remove. To a man of fastidious tastes this choking, sticky dust would be a decided drawback to life on a Brazilian coffee estate.

From the railway station, the party were driven several miles through a broad stretch of coffee trees, and in the very heart of the plantation found a bit of virgin forest several acres in extent, that had been spared the axe, to show how nature clothed that fair land in the days when coffee had no market value. Under the monster trees we passed, marveling at their size and beauty, until without a word of warning we found ourselves in the presence of two giant trees towering above the lesser giants as those would tower above our grandest elms and oaks. It has never been my fortune to stand beneath such majestic forms of plant life as these Jequitibá trees of the Brazilian jungle. The largest specimen measured nearly sixty- two feet in circumference six feet above the ground, or over twenty feet in diameter. Its height was unknown, but certainly exceeded two hundred and fifty feet. The trunk was covered with a regular clear gray bark, and was as columnar as if taken from a Grecian temple, tapering very gradually to the immense crown of spreading branches. Nothing could have given a better idea of the magnitude of this crown than one of the fallen branches which lay like a large tree trunk on the ground, measuring at least four feet in diameter and fifty feet in length. From beneath, we could see that in this tree top a veritable forest of epiphytes and parasites was growing, which added very much to its graceful outlines.

These Jequitibá trees, I believe, challenge the world for majesty of size and form. They are certainly more beautiful than the slender, spire-like Eucalyptus of Gypsland, Victoria; their crowns are far more picturesque than those of the Kauri gums (Jammary) of New Zealand,

although their trunks are similar in shape; and the columnar form of their trunks is more graceful than the rapidly tapering ones of the Sequoia, whose crowns in comparison are as the Norway spruce to the cedar of Lebanon in picturesqueness. On the following day a second visit to this wonderful grove confirmed both Mr. Lathrop and me in the opinion that there are nowhere in the world more beautiful trees than these specimens of *Couratari legalis* (Myrtaceae). I believe there are very few such giants in São Paulo, and any botanist traveling in this state would be repaid by a visit to these trees, which have only been easily accessible to visitors for two years past.

The coffee estate of Dr. Prado is equipped with modern machinery; and many signs of ingenuity in the arrangement of the drying floors, pulping machines, and utilization of dried parchment for fuel, indicate decided progress since the days when the whole berry was dried and the seed removed by a species of husker.

No seed selection is practiced in the planting of the trees, and as yet all these coffee estates, like those of the East Indies, are composed of unselected seedlings, although it is an admitted fact that there is a great variation in the productive powers and other advantageous qualities of the different individuals. As yet no fertilizer save the refuse pulp is applied to the soil, although the latter is gradually becoming exhausted.

With Brazilian coffee at the price it now holds in the New York market there is little money in coffee raising, and the time is near when more labor-saving machinery and improved economical methods of culture will necessarily be employed in order to make the business pay.—DAVID G. FAIRCHILD, *Agricultural Explorer of the U. S. Department of Agriculture.*

CURRENT LITERATURE.

BOOK REVIEWS.

The morphology of spermatophytes.[1]

THIS volume forms the first part of a treatise on seed plants. The reputation of the senior author as a lucid and interesting writer is well borne out in the present instance. The illustrations, which in many cases are obviously due to the junior author, are admirably executed when original, and well chosen where they are drawn from earlier publications. The typography and general make-up of the book are creditable.

As is stated in the preface, the present volume grew out of a course of lectures, accompanied by laboratory work, and it shows throughout a command of the most recent literature and a knowledge at first hand of all the morphological facts which may be investigated in a well equipped laboratory in the temperate region of the United States. It presents original views in regard to morphological terminology and phylogeny, while concerning Ginkgo and the Coniferales a considerable amount of original information is supplied.

The extant Gymnosperms are divided in accordance with the results of recent investigations into four classes, the Cycadales, Ginkgoales, Coniferales, and Gnetales. The information supplied concerning the first class incorporates the important recent works of Ikeno, Webber, and Lang on the gametophyte. The interesting genus Ginkgo is elevated on the basis of the researches of Hirasé, Webber, and Seward into the representative of a group (Ginkgoales) distinct from the Coniferales. We find here a considerable amount of original information concerning the earlier and later stages of the seed, including several good figures and photomicrographs. More space is naturally given to the Coniferales than to any other class of Gymnosperms, since they are the representative group of the present day. In this connection we find an excellent photograph illustrating the heteromorphy of certain coniferous seedlings. The account of the reproductive organs is mainly based on the original examination of *Pinus Laricio*. The photomicrographs and figures in this section are particularly fortunate, especially those figures illustrating the development of pollen and of the embryo. The authors express the opinion that the genus Pinus is perhaps the most specialized representative of the group. Towards the much disputed question of the

[1] COULTER, JOHN M., and CHAMBERLAIN, CHARLES J.: Morphology of Spermatophytes. Part I. Gymnosperms. 8vo. pp. x + 188. *figs. 106.* New York: D. Appleton & Co., 1900. $1.75.

morphology of the ovuliferous scale of the Coniferales they occupy a judicial attitude, although obviously inclining to the view that in the Pinaceae at any rate it is to be regarded as a modified shoot in the axil of the sterile bract. Concerning the treatment of the Gnetales little need be said. Although of necessity presenting no original features it summarizes the most recent literature.

In its treatment of the fossil Gymosperms the present work is far beyond any previous American botanical work. The Cordaitales receive a sufficient consideration, illustrated chiefly by Renault's well-known figures. The extinct cycadoid group, the Bennettitales, is fully discussed from the standpoint of the existing literature, and an interesting account, in part original, is given of the recently discovered microsporophylls of the group, which as yet have been found in a state of suitable preservation only in the United States. The microsporangia occur in synangial sori on the abaxial surfaces of the sporophylls, thus resembling at once Cycas and the marattiaceous ferns. A further interesting feature is that the strobili in this group were not unfrequently bisporangiate, bearing both megasporophylls and microsporophylls.

The work closes with chapters on the comparative morphology, phylogeny, and geographical distribution of the Gymnosperms. As regards comparative morphology the authors have almost entirely excluded vegetative anatomy from their work, and among so many admirable illustrations of the external features and reproductive organs of living and fossil Gymnosperms there are few or none representing anatomical structures of the vegetative organs. The present volume is destined to have such an important influence on the study of Gymnosperms on our continent, that it is impossible not to regret that its authors have not done something to direct the attention of American botanists to the importance of anatomical studies, so much neglected as yet in North America. The work of European palaeobotanists has apparently finally set at rest the claim that the reproductive organs of the higher plants are the only trustworthy guide in matters of morphology and phylogeny. It appears to be established as a result of the work of the late Professor Williamson and his followers that the fibrovascular skeleton of plants is quite as important phylogenetically as the osseous skeleton has proved to be in the case of animals. The Calamities and Sigillariae, for example, were put by Williamson, on account of the constant and characteristic features of structure of their vegetative organs, with the Equisetales and Lycopodiales respectively, in opposition to Brongniart who placed them among the Gymnosperms. The subsequent discovery of their reproductive organs by Williamson and Zeiller only confirmed Williamson's predictions. At the present time the Cycadofilices, a group on anatomical grounds alone considered transitional between the Filicales and Gymnosperms, are in the same position as that formerly occupied by the Calamites and Sigillariae.

The actual condition of our anatomical knowledge seems to justify the general statement that the skeletal features of plants are even more conservative than their reproductive organs, and of quite as great importance in establishing the phylogenetic grouping of the Vasculares.

Turning to phylogenetic matters, the authors consider with Potonié and Scott that the Cycadofilices form the connecting link between Ferns and Gymnosperms. This group they believe to have given rise in all probability to two series, the Bennettitales and the Cordaitales. From the former the Cycadales were derived at a later date, while from the latter stock branched off subsequently the Ginkgoales and Coniferales. The significance of this phylogenetic tree would be more apparent had the earlier part of the book given a better illustrated account of the Cycadofilices and the Cycadofilicinean features of the living and extinct Gymnosperms.

The present admirable volume is indispensable to every botanist, and the reviewer may perhaps express the hope that in the second edition, which will doubtless soon be called for, the authors will add to its usefulness by a well illustrated summary of the relevant points of vegetative anatomy.—E. C. JEFFREY, *Toronto*.

Bergen's botany.

WHEN there began a revulsion against the teaching of botany from the floral standpoint, Bergen's *Elements of Botany* was one of the most helpful text books, because it looked toward the introduction of the student to the more vital phases of botany. The book met instant and increasing success, because it was just different enough from the former texts to attract the teacher who felt the need of a change, and not so different as to repel the teacher who was willing but not anxious to find a new guide.

The *Foundations of Botany* recently issued[2] is in some sense a revision of the older book. It is said to be written upon the same lines, but it differs from the *Elements* in the extension of the portion treating of cryptogams, and in the introduction of a section on ecology. The adoption of these features, which characterize several of the more recent texts, is an acknowledgment that the lines on which they proceed are approved by teachers, and evidence that the publishers desire to meet this demand. The *Flora*, which in the earlier book was wholly inadequate, has been increased fivefold, and, judging from the title-page, is issued in editions adapted to various sections of the country.

The illustrations are all new and almost without exception admirably selected and well made. Many improvements in the text are also evident, and the book is probably as accurate as any text-book now on the market.

[2] BERGEN, JOSEPH Y.: Foundations of botany. 12mo. pp. xii + 412. *figs. 276*. With which is combined: Bergen's botany, key and flora; northern and central states edition. pp. 257. *figs. 25*. Boston: Ginn & Co. 1901.

We regret that the author did not use the metric system; his objection that it is not familiar outside of chemical and physical laboratories is really an indictment of botanical laboratories.

But the book still lacks the treatment of cryptogams which alone can make them worth study. The studies of "types of cryptogams," which section is credited to Mr. A. B. Seymour, have no obvious connection with those of seed plants, and the unfortunate name "spore plants" serves to set the two sharply apart. The chapters on thallophytes, bryophytes, and pteridophytes contain directions for enough laboratory work for a year, but they are not well organized pedagogically, nor in such fashion as to indicate the more important parts. A single chapter on the evolutionary history of plants attempts to furnish a thread of philosophy which has been wanting earlier, but the student is left almost unaided to string his pearls of fact, great and small, into a shapely whole. The great pregnant ideas of alternation of generations, heterospory, and the seed habit lose all their significance unless they are presented in connection with the facts they coordinate.

One naturally expects the *Foundations of Botany* to exemplify, as most books do, the subjects and mode of presentation which the author thinks best for the schools. But we find it difficult to interpret Mr. Bergen. One looks for the present book to show advance along the lines which characterized the *Elements*. On the contrary it seems to encourage the teacher of "analysis" by bringing to his hand a better flora; it meets the demand for ecology by organizing a section on this subject; it gives the histological teacher ample scope for the use of microscope and reagents; it does not develop further the physiological features. What is the teacher to do? Is the book a guide to wise botanical instruction or simply a book catering to all tastes? This uncertain pedagogical sound seems to us to make it doubtful whether *Foundations* will prove as satisfactory as *Elements*, which had in its time a mission that it excellently fulfilled.— C. R. B.

Two books on mushrooms.

POPULAR books on mushrooms multiply. The latest two issue from New York. There are many good things to be said for Miss Marshall's account[3] of the more conspicuous Ascomycetes and Basidiomycetes. In the first place, the figures and diagrams are excellent and so numerous that eighty-three of the hundred and more species described are well illustrated. A number of the half-tone plates are printed in colors and the remainder in black and white. The descriptions are simple and clear, and there is also much interesting information appended concerning habits and the edible and poisonous properties

[3] MARSHALL, NINA L.: The mushroom book. A popular guide to the identification and study of our commoner fungi, with special emphasis on the edible varieties. Imp. 8vo. pp. xxvi + 167. With many illustrations in color and black and white. Doubleday, Page & Co. New York, 1901. $3.00.

of the important species. Miss Marshall has introduced an elaborate key at the beginning of the book, designed to lead the reader directly to the genus. This naturally presents the complexities inherent in a subject of such acknowledged difficulty. One notes some inconsistencies. "For convenience," Craterellus is described among the "fungi with gills," but even then the writer failed to find its place in the key. Such looseness reacts in the end on the general worth of the book. Then it seems a pity that Miss Marshall should attempt to describe in general language, and sometimes even figuratively, structural characters and physiological activities that are fundamental to all careful observations of fungi. Such expressions have a pseudo-simplicity, which deceives and misleads instead of enlightening the novice.

The second work is issued as a *Memoir* of the New York State Museum, by the botanist, Mr. Charles H. Peck. The forty-eighth report for 1894, containing quarto colored plates and descriptions of edible fungi, was in great demand, so that several editions were exhausted almost as soon as issued. The forty-ninth, fifty-first, and fifty-second reports, contained illustrations and descriptions of thirty-three species. The work of the past year adds fourteen species to the list. On account of the great demand for these reports by mycologists and mycophagists, the parts on edible fungi are brought together to form the present memoir, illustrations and text having been revised when necessary.[4] Thus the forty-eighth report with sixty-nine species and the present memoir with forty-eight species illustrate to date the edible and poisonous fungi of the state. The character of descriptions and plates is like that of former reports. The figures are stiff and mechanical in drawing and rather crude in coloring. A comparison of the two books in this respect shows the great superiority of photographs and half tones over anything but the most expert and artistic drawing, and the most expensive reproduction.— B. M. DAVIS.

MINOR NOTICES.

THE REPORT of the state botanist of New York for 1899 has just appeared in its usual dilatory fashion. It contains descriptions of numerous new fleshy fungi, and three colored plates.— J. M. C.

THE THIRD FASCICLE of Schumann's *Blühende Kakteen* (Iconographia Cactacearum) has appeared, containing beautiful illustrations of *Echinocactus longihamatus* Gal., *E. Monvillei* Lem., *E. Fordii* Orcutt, and *E. Knippelianus* Liebn.— J. M. C.

THE SEVENTH FASCICLE of the first volume of "Illustrations de la Flore du Congo," by Wildeman and Durand, has just appeared, containing *plates*

[4] PECK, CHARLES H.: Report of the State Botanist on Edible Fungi of New York, 1895–1899. 4to. pp. 133–234. *pls. 44–68.* Albany: University of the State of New York. 1900.

73–84. The publication continues its high character, and the plates represent the best of the lithographer's art.—J. M. C.

ONE of the most recent additions to the local floras of Britain is the *Flora of Cheshire*,[5] prepared from the manuscripts of the late Lord de Tabley. It gives in great fullness an account of the floral districts, the ecological conditions, and a list or species accompanied by a detailed account of stations.—J. M. C.

THE FIRST FASCICLE of the third volume of Pittier's *Flora of Costa Rica*[6] has appeared. It contains the "Filices, Equisetaceae, Lycopodiaceae, Selaginellaceae, and Rhizocarpaceae," by H. Christ. Seventeen new species and ten new varieties of ferns are described, besides one new species and two new varieties of Lycopodium.—J. M. C.

BILTMORE BOTANICAL STUDIES is the title of a new botanical journal, to be "issued at irregular intervals," and to include papers by the director of the Biltmore Herbarium and his associates. The first number was issued April 8, 1891, and includes the following papers: C. D. BEADLE and F. E. BOYNTON, Revision of the species of Marshallia (7 species, 3 of them new); C. L. BOYNTON and C. D. BEADLE, Notes on certain coneflowers (including 5 new species of Rudbeckia); T. G. HARBISON, New or little known species of Trillium (3 new species); C. D. BEADLE, New species of thorns from the southeastern states (21 new species of Crataegus); C. D. BEADLE, a shrubby oak of the southern Alleghanies (*Q. Boyntoni*). The journal is very handsomely printed and illustrated.—J. M. C.

PROFESSOR E. L. GREENE has begun the publication of a series of papers bearing the title *Plantae Bakerianae*.[7] It is to contain lists of plants collected by Mr. Carl F. Baker and his colleagues and distributed to various herbaria on both sides of the Atlantic. The first volume is to include the collections of 1898 by Messrs. Baker, Earle, and Tracy in southern Colorado, and the fascicle now at hand extends from Fungi to Iridaceae. A prefatory narrative by Mr. Earle describes clearly the region traversed, and gives an adequate background for the list of plants which follows. The fungi are by Messrs. Earle and Tracy, and the list includes descriptions of thirty-one new species. The Polyporaceae have been determined by Professor Underwood, the lichens by Professor Fink, and the grasses by Professor Tracy; otherwise the determinations are by Professor Greene, who includes descriptions of new species of Zygadenus and Allium.—J. M. C.

[5] TABLEY, LORD DE: The flora of Cheshire. Edited by Spencer Moore, and with a biographical notice of the author by Sir Mountstuart Grant Duff. 8vo. pp. cxiv + 399. London: Longmans, Green, & Co. 1899. $3.50.

[6] PITTIER, H.—Primitiae Florae Costaricensis. Vol. III. pp. 1–69. San José de Costa Rica. 1901. 75 cents.

[7] Plantae Bakerianae 1: 1–52. 23Ja1901. Fungi to Iridaceae. Catholic University of America, Washington, D. C. Price 40 cents.

NOTES FOR STUDENTS.

W. A. WHEELER[8] has published an ecological account of the vegetation of southeastern Minnesota in connection with a list of the species collected there. The paper is accompanied by several excellent heliotypes.—H. C. COWLES.

E. M. WILCOX has investigated[9] a rhizomorphic root-rot of fruit trees that is doing great damage to the peach, apple, and cherry trees of the southwest. The fungus concerned is described as a new species, *Clitocybe parasitica*, and is also found infesting oak trees. A very extensive bibliography and several plates accompany the report.— H. C. COWLES.

CORRENS has shown experimentally[10] that in *Mirabilis Jalapa* only one pollen grain out of five, and two ovules out of three, are fit, while in *Mirabilis longiflora* one pollen grain out of four, and one ovule out of two are fit. Therefore the chances of fertilization increase with the number of pollen grains used in pollination, and the progeny are stronger.—C. R. B.

IN A RECENT number of Engler's yearbook[11] there is an account of the recent attempts to secure a uniform nomenclature in plant geography. Warburg's address before the Berlin geographical congress in September 1899 is given, as is also the resolution passed by the Paris botanical congress in 1900. Engler makes an appeal for contributions that will tend to clarify the various questions, offering to publish them in the yearbook. Particularly with reference to the use of the word "formation" is there need of a general understanding.—H. C. COWLES.

VON SCHRENK has published a preliminary report on diseases of New England conifers[12] which contains a good deal of interesting material. General remarks are made on the conditions in the New England forests, and on the relation of fungi to forest problems. Several fungi, mainly Polypori, are described with especial reference to the mode of occurrence and the effect on the tree. A number of excellent plates accompany the report. Dr. von Schrenk's work has often been noticed in this journal, and must be highly commended both for its botanical importance and its practical aspect.—H. C. COWLES.

IN A SHORT paper entitled "A contribution to the natural history of marl, C. A. Davis[13] shows conclusively that water plants, especially Chara

[8] Minn. Bot. Studies, ser. 2, pt. 4. 1900.

[9] Bull. 49, Oklahoma Agric. Ex. Sta. 1901.

[10] Berichte d. deutsch. bot. Gesells. **18**: 422–435. 1900.

[11] Eng. Bot. Jahrb. **29**: Beiblatt 66, 23–30. 1900.

[12] Bull. 25, U. S. Dept. of Agric. Div. of Veg. Phys. and Path. 1900.

[13] Jour. Geol. **8**: 485–497. 1900.

and blue-green algae, are of great importance in marl formation. The calcareous incrustations, which give rise to marl upon the decay of the plants, are formed by the deposition of $CaCO_3$ when the CO_2, which caused it to remain in solution, is used in photosynthesis. The oxygen set free in photosynthesis also causes the precipitation of $CaCO_3$. One interesting fact brought out by the study is that plants vary widely in respect to the incrustations, indicating selective processes not yet understood.—H. C. COWLES.

MISS ELIZABETH DALE, in a communication to the Royal Society, London, through Professor H. Marshall Ward, shows that the abnormal outgrowths, or intumescences, in *Hibiscus vitifolius* Linn. are due to pathological conditions, being formed in a moist atmosphere, provided there is also adequate light and heat. The immediate effect of the damp atmosphere is to check transpiration. This, in its turn, by blocking the tissues with water, disturbs the normal course of metabolism, and so leads (when the light and heat are sufficient) to abnormal development of certain regions. The formation of these outgrowths is accompanied by the production of oil, which is not found in normal leaves. Its presence suggests that events similar to those occurring in succulent plants are taking place, viz., reduced respiration and the development of osmotically active substances in excess. It is therefore probable that the intumescences are due to the local accumulation of osmotically active substances, produced under the abnormal conditions.—H. M. WARD.

THE LITERATURE of the first mitosis of the spore mother cell of Lilium shows a wide divergence of opinion in regard to the phenomena involved, but there are certain stages which have been constantly observed. How these stages are derived from one another is the most debated question. In a recent paper Professor Dixon[14] figures and describes six well ascertained stages, and then proceeds into the debated territory. Nearly all observers describe a longitudinal splitting of the entire thread just before the segmentation into chromosomes, but Professor Dixon believes that the stage so constantly observed arises from the looping on each other and approximations of two portions of the thread. Several very suggestive objections are urged against the commonly accepted interpretation. Although believing that each of the two twisted portions undergoes a longitudinal splitting while still in the spirem stage or immediately after differentiation into chromosomes, regarded as a second longitudinal splitting by Guignard and others, the author believes that this is the first and only longitudinal splitting. A series of very clear diagrams illustrates the author's interpretation of the composition of the chromosomes and their behavior during the later phases

[14] On the first mitosis of the spore mother cells of Lilium. Notes from the Botanical School of Trinity College Dublin 4: 129–139. *pls. 7–8.* 1901.

of mitosis. According to this interpretation there is no qualitative reduction during the first division of the spore mother cell.—CHARLES J. CHAMBERLAIN.

THE LIFE HISTORY of *Schizaea pusilla* has been investigated recently, and the results form the first fairly complete account of this interesting fern.[15] The material was collected at Forked river, New Jersey, in July 1900. Sections do not seem to have been made except in the study of the root, stem, and leaf. While the peculiar gametophyte and the general aspect of the young sporophyte are shown more clearly without sections, one cannot help feeling that the account of the development of the antheridia and archegonia, and also of the very young sporophyte, would have been more satisfactory if the study had been made from microtome sections. The gametophyte is composed of numerous erect branching filaments which have a somewhat uniform diameter and bear a striking resemblance to the protonema of a moss. The filaments persist until the young sporophyte has attained considerable size. The archegonia are not imbedded, but are entirely free, in general appearance suggesting the archegonia of certain liverworts. The archegonium originates as a single superficial cell which gives rise to a row of three cells. From the outermost of these is formed a neck consisting of four tiers of cells with four cells in each tier. From the middle cell comes the central cell which gives rise to the neck canal cell, the ventral canal cell, and the egg. The basal cell forms the venter. One figure illustrating the development of the antheridium shows a row of three cells. The outermost cell "becomes large and globular and cuts off a cap cell at the summit, with the wall oblique. The large cell divides up into the mother cells of the antherozoids and one ring cell." The anatomy of the root, stem, and leaf is described in detail.—CHARLES J. CHAMBERLAIN.

DR. A. KLETT[16] has recently studied anthrax to ascertain if it is possible to produce the spores in a culture of the bacillus grown under artificial anaerobic conditions, and to observe the effect of nitrogen and hydrogen upon the growth of the colonies. For the nitrogen experiments Buchner's tubes containing pyrogallic acid and caustic potash were used. By this means the oxygen and carbon dioxid of the atmosphere in the sealed tubes were absorbed, leaving nothing but nitrogen. For the hydrogen experiments he employed Kipp's apparatus for generating the hydrogen, and Botkin's apparatus for growing the cultures in plates and in liquid media. Although every precaution was taken against the possibility of error, Klett shows by careful experimentation that spore formation in anthrax is independent of the presence of oxygen. He was enabled to obtain a rich growth of the bacillus with

[15] BRITTON, ELIZABETH G. and TAYLOR, ALEXANDRIA: The life history of *Schizaea pusilla*. Bull. Torr. Bot. Club **28**: 1–19. *pls. 1–6*. 1901.

[16] Die Sporenbildungen des Miltzbrandes bei Anaërobiose. Zeit. f. Hyg. u. Infectionskrank. **35**: 420. 1900.

abundant spores in an atmosphere of nitrogen. In the hydrogen atmosphere, on the other hand, there appeared only a very meager growth of the colonies, without a trace of spores. From these observations Klett opposes the more commonly accepted view that the presence of free oxygen is a necessary condition for the formation of spores in the anthrax bacillus, and holds that spores cannot be formed in an atmosphere of hydrogen owing to the retarding effect of this gas upon the growth of the colonies. He further concludes that it is not the presence or absence of oxygen that determines the growth and the development of spores in the bacillus, but that every gas has its specific influence in this respect. The paper is a most interesting and valuable contribution to the controversy of spore formation in anthrax, and it also has an important bearing on many experiments where hydrogen, considered as an inert gas, has been employed to bring about an anaerobic condition.—A. A. LAWSON.

ITEMS OF TAXONOMIC INTEREST are as follows: L. DIELS (Engler's Bot. Jahrb. **29**: 577–659. 1901) has completed his account of the flora of central China, the closing part extending from Bignoniaceae to Compositae. Besides numerous new species, *Kolkwitzia* (Caprifoliaceae) and *Hoeckia* (Valerianaceae) are described by Graebner as new genera.— O. E. SCHULZ (*idem* 660–735. *pls. 6–8*) has published a monograph of *Melilotus*. A discussion of the history, morphology, teratology, biology, and geographical distribution of the genus is followed by a detailed presentation of the twenty-two recognized species, three of which are new.— S. SOMMIER and E. LEVIER (Acta Horti Petropolitani **16**: 1–586. *pls. 1–49*. 1900) have published an elaborate account of the plants collected in the Caucasus in 1890, illustrated by forty-nine fine lithographic plates. The list includes cryptogams as well as seed plants. More than a hundred new species are described, and still more numerous new varieties.— W. LIPSKY (*idem* **18**: 1–146. 1900), in a contribution to the flora of middle Asia, has described numerous new species, and with them two new genera of Umbelliferae, *Korshinskia* and *Galagania*.— N. L. BRITTON (Torreya **1**: 21. 1901) has described a new Senecio (*S. Crawfordii*) from Pennsylvania.— M. L. FERNALD (Rhodora **3**: 43–56. 1901) has published a synopsis of the northeastern species of Carex of the subsection Vesicariae, recognizing eleven somewhat polymorphic species and describing seven new varieties.— F. LAMSON-SCRIBNER (Div. Agrost. Circ. 30. 8 Mr 1901) has described new species of Ichnanthus, Agrostis, Bouteloua (2), and Danthonia, besides numerous new varieties and combinations.— E. L. MORRIS (Bull. Torr. Bot. Club **28**: 112–122. *pl. 12*. 1901), in his second paper on N. Am. Plantaginaceae, has described six new species of Plantago.— G. N. BEST (*idem* 123–131. *pls. 13–14*), in a revision of the N. Am. Species of Heterocladium, recognizes six species and varieties, three of which are described as new.— J. M. C.

OPEN LETTERS.

THE NAMES OF OUR FERNS.

THE deadly parallel has always been a striking method of impressing a point. When its bald statements are unqualified it seems to mean more than the facts will warrant, and it is expected to kill at long range. In a recent issue of the BOTANICAL GAZETTE, Mr. Fernald has made use of it to show the supposed instability of the "reform movement," but does not note the fact that ten of the fifteen changes of which he accuses me were made in accordance with changed conceptions regarding the limitations of genera, and consequently have no bearing whatever on the point he is attempting to illustrate. His illustration in other respects is very happily chosen, and its full import will become apparent when we add the part he forgot to use. For the benefit of the younger generation of botanists who, like Mr. Fernald, might be misled to suppose that all the changes of plant names have been proposed by the "reform movement," I will add from the same group the changes of trans-Carline origin that have been made in the past generation as follows:

FERN NAMES USED IN GRAY'S MANUAL, FIRST EDITION.	FERN NAMES USED IN GRAY'S MANUAL, SIXTH EDITION.
Polypodium Phegopteris L. (2, 3, 4).*	Phegopteris polypodioides Fee.
Polypodium hexagonopterum Michx. (2, 3, 4).	Phegopteris hexagonoptera Fee.
Polypodium Dryopteris L. (2, 3, 4).	Phegopteris Dryopteris Fee.
Struthiopteris Germanica Willd. (2, 3, 4, 5).	Onoclea Struthiopteris Hoffm.
Allosorus gracilis Presl. (2, 3, 4).	Pellaea gracilis Hook.
Pteris atropurpurea L.†	Pellaea atropurpurea Link.
Scolopendrium officinarum Smith (2, 3, 4).	Scolopendrium vulgare Smith.
Dicksonia punctilobula Hook. (2, 3, 4, 5).	Dicksonia pilosiuscula Willd.
Dryopteris Thelypteris [A. Gray].	Aspidium Thelypteris Swartz.
Dryopteris Noveboracensis [A. Gray].	Aspidium Noveboracense Swartz.
Dryopteris intermedia [A. Gray].	Aspidium spinulosum intermedium D. C. Eaton.
Dryopteris dilatata [A. Gray].	Aspidium spinulosum dilatatum D. C. Eaton.
Dryopteris rigida [A. Gray].	Aspidium Boottii Tuckerm.
Dryopteris cristata [A. Gray].	Aspidium cristatum Swartz.
Dryopteris Goldiana [A. Gray].	Aspidium Goldianum Hook.
Polystichum aculeatum Roth.	Aspidium aculeatum Braunii Koch.
Polystichum acrostichoides Schott.	Aspidium acrostichoides Swartz.
Polystichum Lonchitis Roth.	Aspidium Lonchitis Swartz.
Osmunda spectabilis Willd. (2, 3, 4).	Osmunda regalis L.
Botrychium lunarioides Swartz (2, 3, 4, 5).	Botrychium ternatum Swartz.
Botrychium Virginicum Swartz (2, 3, 4, 5).	Botrychium Virginianum Swartz.

*These numbers indicate the successive editions in which this same form appeared.

†This passed through the intermediate stage of Allosorus atropurpureus [A. Gray] before reaching its final form.

Or in other words, out of the fifty species of ferns from the northeastern states described in the first edition of Gray's *Manual*, 21, or 42 per cent., bore different names in the last issue of the same work, and more than that, eight of these suffered a change in the specific name also, not including those whose relative rank was changed from variety to species or *vice versa*. Surely the trans-Carlines will have to admit that this exceeds the 25 per cent. which Mr. Fernald cites as such a horrible example. But after all, what matters it if 99 per cent. are changed so long as the change is an evolution towards a more stable system based on principles less unseaworthy than the personal preference hit-or-miss system of Kew and Berlin?

LUCIEN M. UNDERWOOD.

NEWS.

MR. B. E. FERNOW, Director of the New York State School of Forestry, Cornell University, will give a course of lectures on forestry at The University of Chicago during the summer quarter.

DR. ROSCOE POUND, whose studies on the phytogeography of Nebraska have made him well known as a botanist, has been appointed a member of the new Supreme Court Commission, which is to assist the Supreme Court of Nebraska to clear up its docket. The work of the court is far in arrears, and the commissioners are *de facto* justices. Dr. Pound is winning laurels in his vocation as well as in his avocation.

MR. EDWARD F. BIGELOW, the editor of the Nature and Science department of *St. Nicholas*, has had prepared compressed tablets after Sachs' formula for making nutrient solution. Two of the tablets make a pint of the solution of usual strength. Two forms are made, those with and without ferric chlorid. The tablets are exceedingly convenient. Doubtless they can be purchased through Mr. Bigelow.

THE DEATH of J. G. Agardh on January 17, in his 88th year, removed a notable student of marine algae. His first paper on marine algae was published in 1836, and his last paper has just come to the writer's desk, not all the proof of which did the author live to read. His greatest work is the *Species Genera et Ordines Algarum*, and to this his last paper was a supplement. A brief résumé of his work appears in the *Journal of Botany* for April. His great collection, full of types, passes under the immediate control of the University of Lund.

THE following circular letter has been sent to many botanists in this country. As the committee find it difficult to ascertain the addresses of American botanists they desire that all botanists who may see this notice send their application for membership in the proposed association to DR. J. P. LOTSY, *Wageningen, Holland*, by postal card, even though they may not receive a copy of the circular:

> The undersigned, convinced that a better organization of the botanists of the different countries would contribute in a most desirable manner to our mutual aim, viz., the progress of botany, have the honor to invite you to become a member of a new society to be called the *International Botanical Association*.
>
> A general meeting will take place at Geneva, Switzerland, on the 7th of August next in the botanical laboratory of the university at 10 A. M.

During this meeting several questions will be submitted to the judgment of its members, and you are invited to propose orally or in writing such measures as you think it desirable that the new society should adopt.

The chief object of the association will be the establishment of a bibliographic periodical abstracting in a perfectly impartial manner all botanical publications in such a way that the important will be separated from the less so.

It will not — as some periodicals do — devote page after page to publications of questionable value, while most important works are put off with two or three lines or even not mentioned at all.

The abstracts will — at the desire of the contributors — be published in English, French, or German. All will be submitted to the judgment of an editor nominated by the association and responsible to it.

It is most desirable that the membership be as wide as possible, since this is the only way of making membership inexpensive. Under no circumstances will the membership cost more than $6, including the free delivery of the periodical.

We wish to call your attention to another great advantage of the new society; by its means members who live in different parts of the globe will be brought into more intimate contact one with another and this will greatly facilitate the procuring of material for investigation and demonstration.

Under certain conditions to be discussed, accepted, or rejected at the general meeting in Geneva, Switzerland, the proprietors of the *Botanisches Centralblatt* have consented that their journal become the property of the association.

The call is signed by Bornet, Borzi, Bower, Celakovsky, Chodat, Fairchild, Farlow, Goebel, Lotsy, Nawaschin, Raciborski, Rauwenhoff, Schimper, Stahl, Warming, and v. Wettstein.